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THE NECESSITY FOR AFFORESTATION IN THE DRY AREAS*

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The value and utility of forests to man and industry are usually only realized when the forests of a country have been largely destroyed by so-called progress. This is particularly so in the drier areas where the rainfall is 40 inches per annum. One of the most striking examples is that of the American "dust bowl" where, in the short space of some three generations, intensive agriculture which the locality and climate would not stand has produced a devastation of about a million square miles. The destruction was practically complete before it was realised.

The progressive deterioration of conditions in India is well demonstrated by two simple examples. It has been recorded that when Alexander came to India in 326 B.C. his army and his elephants camped in a *sal* forest near where Lahore now stands. This was only about 2,300 years ago, but now there is not a *sal* tree within hundreds of miles of Lahore. A second example is that of the ruins of the old civilization of 400 or 500 years ago at Bijapur in the Deccan which show that in those times there must have been extensive forests to supply the fuel and timber for daily use, rich fields to produce the food for the people, and pasture lands for animals including the horses and elephants of the army. Today that land is sparsely populated and has neither pasture nor forest. Famine is the rule and not the exception.

Some of the forests of India, notably the tropical evergreen forests of the wetter regions, are undoubtedly in their original majestic state, but by far the greater part have been directly influenced by human activities. In the earlier stages of occupation of land the forest has everywhere been looked upon as an enemy of man, and its destruction has been regarded as indicating progress. This attitude persists where local conditions are kind and where the pressure of population is not great, but, where the forest has been destroyed and, as a consequence, fields have largely gone out of cultivation, the people are gradually coming to realize the value of the forests they have destroyed.

The extent to which this devastation has gone on is at once apparent to any traveller who journeys by train from Calcutta to Peshawar and sees the Gangetic Plain, the Punjab and the North West Frontier. Scarcely a forest is seen along the whole way. Similarly, the traveller can see the bare slopes of the Himalayas where only a few remnants of formerly luxuriant forests remain. In Central and Peninsular India also one sees the bare hills from which not only the vegetation has disappeared but, as a result, the soil also has been washed away and bare rock remains. This is not all; one also finds abandoned fields, abandoned because in these dry areas the clearing of the forest and opening of the fields only results in a short period of fertility. This is because the soils are naturally poor and depend on the annual supply of organic matter by the leaf fall of the forest cover to maintain their small fertility. When the forest is cut down and burned, this leaf layer is also burned. This gives a little manure to the soil (and hence a short period of (fertility), but the replenishing supply has been stopped by the clearing of the forest. In a short while, the field crops themselves, and the exposure of the bare soil to the sun, wind and rain quickly deplete it of its nutrients and leaves it incapable of supporting even a field crop. Nature herself would reclothe much of these bare spaces if she were left to herself, but ever destructive man continues to graze excessive numbers of inferior animals and makes the devastation permanent.

*Paper read at the Seventh Silvicultural Conference (1946), Dehra Dun, on item 3—The Afforestation of dry and Desert Areas.

The forester is called upon to remedy these depredations but usually is not called in until it is too late for a quick solution to be possible. He has to try and recover the denuded hill-sides, to stop the washing of the soil, silt, sterile sand, gravel, and boulders which cover up the agricultural fields below. He has to manage the forests that remain so that the villagers are supplied with their timber and fuel and pasture, without at the same time making large gaps in the forest which start soil deterioration and erosion.

The present area of British India that is covered by really good forest is only roughly 12 per cent. For comparison with this, a list is given below of the forest areas of some European countries, most of which are much more settled, and in which scientific forestry started and has been carried on for many centuries.

Country.	*Forest area as percentage of total land area.*
Austria	38
Belgium	18
Czechoslovakia	34
Denmark	9
Finland	74
France	19
German Reich (including Austria)	24
Great Britain	6
Greece	19
Hungary	13
Italy	20
Latvia	27
Netherlands	8
Norway	21
Poland	23
Portugal	22
Roumania	24
Russia (European)	44
Spain	14
Sweden	23
Switzerland	55

The average of the above figures for 21 countries is 26 per cent, but this is only a rough figure showing what the experience of hundreds of years has indicated to these countries as the proportion of the land which must be under forest in order that the country should prosper. HOWARD (1944) in his *Post war forest policy for India* recommends that this country should have some 25 per cent of its land under forest. *This is more than double the present forest area*, and, as far as British India is concerned, it means the creation of at least 100,000 square miles of new forest. In addition, the existing forests are badly distributed and the villages in hundreds of thousands of square miles of the plains of central and northern India have no forests near them.

The great Indian desert of Sind and Rajputana covers some 100,000 square miles, but the desert or desert conditions extend in the west in Sind up to the Baluchistan foothills except for a comparatively narrow strip along the Indus. Similar conditions prevail in the north west extending through Dera Ghazi Khan in the Punjab and Dera Ismail Khan in the North West Frontier Province, in the north in the Muzaffargarh, Mianwali, Multan and Montgomery districts of the Punjab and in the many states that are found to the north-east and east. All these constitute an area as big as the "official" desert and together with it make some 200,000 square miles or nearly one-eighth of India.

Recent surveys of the past 10 years when compared with the older surveys of 50 or 60 years ago show that the desert has been spreading outwards in a great convex arc roughly from Bahawalpur through Ferozpore, Patiala, and Meerut, to Aligarh and *Kasganj at the rate of about half a mile* per year over the last fifty years. This means that approximately three hundred square miles of fertile land are being converted into desert every year. It is true that in recent years thin fingers of irrigation have also extended into some parts of this area, but in comparison with the general problem they are almost negligible.

Apart from this spread of the desert, very serious erosion is occurring in many parts of the country and the fields are going out of cultivation. In some places this is due to the loss of the fertile top soil which is washed away by the rain or blown away by the wind, while in others it is caused by the deposition of sterile sand, gravel, and boulders washed down on to them from higher land. Further, in many places, irrigation is causing a serious rise of the water table which often brings up salts to the surface and prevents cultivation. In some areas the water table has even risen to the surface itself.

At the recent convocation of the Forest Colleges in Dehra Dun, Sir Jogendra Singh the Hon'ble Member for Agriculture ably expresed the present position when he said, "The time has now come when man who has destroyed the forests and put the soil under agriculture is compelled to restore the forests so that agriculture may prosper. If agriculture is to prosper we must convert the area under forests from 12 per cent to 25 per cent".

The greater part of this increase of forest area will of necessity have to be in the dry and arid areas, and these occupy roughly one-third to one-half of the country. The creation of new forests in these dry areas will not only help to ameliorate the rigours of the climatic conditions and help to arrest the depredations of erosion but it will also supply the villager with the three "Fs" essential to his daily life—food, fodder and fuel—and hence help to release the precious cowdung for its rightful purpose. The cowdung now burned as fuel has been estimated adequately to manure about 13 per cent of the whole of India's cultivation.

Combined with this actual increase of forest, must be promoted what has come to be known as "farm forestry". Each agricultural holding must grow its own shelter-belts, windbreaks, hedges, and wood-lots, and be self-supporting for fuel, small timber, and grazing.

This increase in forest can be accomplished in many ways, such as the general afforestation of waste lands, canal banks, roadsides and railway lines, and also by irrigated plantations and the fixation of shifting sands both coastal and inland.

The problem is immense, and yet it must be solved since it is so clearly essential to the future of India. The present generation has inherited this legacy from its ancestors who were not as "forest conscious" as modern advance of knowledge demands. Knowing fully well the dangers ahead it is not possible to conceive of doing greater harm to the welfare of posterity than by allowing matters to drift. That the solution of the problem is possible has been demonstrated by arid area afforestation research in a number of provinces. This work has shown that even in places with as low a rainfall as 5 to 10 inches vegetative cover and low tree growth can be raised. The essential conditions for success are:—

(1) complete closure to grazing animals such as camels, goats and sheep.

(2) a *contour* soil working before sowing (in lines about 6 inches by 6 inches section).

(3) sow plenty of seed, sow it early, and sow in contour lines. Do not broadcast seed.

(4) work the soil in between the lines after each shower of rain but do not disturb the plants. NEVER let the soil surface cake.

(5) keep down the weeds in the lines but do not disturb the local vegetation which appears between the lines.

(6) thin out the plants in the lines as and when necessary.

It will involve a large amount of money which will have to be found, and a large expert staff which will have to be trained. This staff will have no easy job and will have to live under difficult conditions. They will have to be well paid and well housed. Above all they must have the confidence of the local people with whom they will have to work. In addition, it will need the co-operation of all provinces and states, for one passive unit in any land management scheme can vitiate its results. The need for this co-operation is seen from the example given above of the desert spread. The tackling of this problem concerns Sind, the Punjab, the United Provinces, Delhi province and many states. The successful solution of the probem can only be achieved with the complete co-operation of all the provinces and states within the desert fringe.

The work on this problem is no new thing for irrigated plantations were started in the plains of the Punjab as long ago as 1866. *Casuarina* plantations to fix the drifting sands of the seashore and turn them to a useful purpose date back to 1868 in the Madras and Bombay provinces. Reclamation of ravine land in the United Provinces and *chos* training in the Punjab have been going on for many years. It is only recently, however, that the immensity and the urgency of the problem have been realized and large-scale enterprises, such as the land improvement work of Bombay, have been started.

Although the problem is immense it is not impossible; the examples of what has been done in recent years in other countries should be continually before us and serve as an impetus. The United States are seriously and successfully tackling a man-made "dust bowl" of a million square miles, while Canada has its own problems of denuded areas of some half a million square miles in the middle of the dominion.

One of the biggest problems in many of the areas to be taken up is what species to grow, and this immediately raises the question of what can we grow? In such a scheme of things it is advisable not only to select timber or fuel producing plants for afforesting particular areas, but also, as far as possible, to endeavour to find those which yield other products of economic importance, such as drugs, tanstuffs, fibres, flosses, gums and resins, fats, essential oils, etc. Although the great need at present is the afforestation of dry and desert areas, yet it is obvious that preference should be given to such plants as would play an important role in the economy of the country by meeting the increasing demands of developing industry and the household needs of the people. In other words, the aim should be not only to raise forests, but forests of the greatest economic importance possible under the conditions.

The subject was to be discussed at the sixth silvicultural conference at Dehra Dun in April 1945 and for this purpose a list of possible species was drawn up. The list was compiled from many sources, including books, ledger files, tour notes and above all general touring experience. It was warmly welcomed by the conference which passed a resolution that it should be published expeditiously. In consequence it appeared in the *Indian Forester* in February, 1946. It was being continually revised and brought up to date, but this is an endless task and a halt must be called somewhere.

In consequence *Indian Forest Bulletin* No. 133 (*Silviculture*) "The afforestation of dry and arid areas" by R. L. Badhwar, A. C. Dey and A. L. Griffith of the silviculture and chemistry and minor forest products branches of the Forest Research Institute has now been published.

The list contains not only species indigenous to India but also possible useful exotics, for it is always likely that some exotics may prove of outstanding value. It is probable that many must be tried before the most suitable are found. We must remember the successful introduction of such species as the blue gum (*Eucalyptus globulus*) and the wattles (*Acacia decurrens* and *A. mollissima*) in the Nilgiris and Pulneys, and of the mesquite (*Prosopis juliflora* and *P. glandulosa*) in the plains of the Punjab and Sind.

In the first part of the bulletin the species are given in alphabetical order in three sections (1) trees, shrubs and herbs, (2) Indian grasses and (3) foreign grasses, together with very brief notes on each species. At the end they are all summarised in a table showing at a glance the possible areas where they can be tried.

The list is illustrated by two maps, one of the rainfall distribution and the second of the vegetational types of the drier areas of the country.

A first attempt at such a list is bound to be incomplete and to contain errors. We shall be grateful, therefore, if readers will send in additions, corrections and criticisms, for it is only with such help that we can improve the list and keep it up to date

REFORESTATION OF FLAT DENUDED LAND IN DHALBHUM FOREST DIVISION

By J. N. Sinha.

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The Dhalbhum division as at present constituted, covers part of Singhbhum and the whole of Manbhum district. The Singhbhum part of it coincides with the Dhalbhum civil sub-division. The reforestation work described in this article covers only the work done on flat denuded lands in Dhalbhum (Lat. 22° 18′ N. to 22° 44′N and Long. 86° 12′E to 86° 52′E), although bare hillocks both in Dhalbhum and Manbhum are also being reforested. The mean temperature in Dhalbhum varies generally from 53° to 105° F. and rainfall is about 45 inches in the year, confined mostly to the period June to September.

Dhalbhum is topographically divided by the Subarnarekha river into two more or less distinct regions. The South-eastern part—starting from Ghatsila, is altogether flat and soft, in sharp contrast with the rest which is hilly and hard. In the former (where the reforestation work is located) the soil is sandy loam with outcrops of *murrum* and for miles in certain localities not a piece of stone may be available. Paddy land, populous villages, and pure *sal* (*Shorea robusta*) forest characterise the landscape. The forest however has been ruthlessly destroyed. When the forest department appeared on the scene in 1936 (government having taken a 45 year lease of the Dhalbhum forest under section 38, Indian Forest Act) the *sal* forest looked like a wheat field where you could not sit and hide yourself. And yet this was the best of the wreck. Vast stretches of land, dismally and heart-breakingly vast, lay wholly denuded of all vestige of vegetation. Here the tree roots had been dug up and removed. This was done partly to find fuel from somewhere and partly to spite the proprietor of Dhalbhum estate between whom and the *raiyats* relations were strained. In thirteen villages near Bahragora in the extreme south-east the flourishing *sal* forest was razed to the ground by the inhabitants within a night and a day for the sheer reason that the estate had disputed the peoples' right therein. Here was an unfortunate case of cutting away one's head to prevent headaches To-day this landscape laments that loss. For miles and miles, to the ends of vision, you can see the forlorn undulating land like the child-bereft mother silently heaving her breast in sighs. And when the wild wind moans through and around this land of death, one feels as if ghosts of the dead children have risen to appeal to their helpless mother.

When the forest department demarcated the forests it took in all the green washes, for the future lay with them. Today after the work of only 10 years those "wheat fields" have transformed themselves into a fine forest of *sal* saplings. We also took in as much of the denuded land as was available within the scope of the lease which was primarily for forest covered lands. The extent of waste lands in charge of the forest department is very limited compared to the great expanses that lie all around. Even so the waste land in our charge is quite a mouthful and needs great concentrated work to reconvert it into forest. If we do up this much well and quickly we shall justify ourselves as a nation building department and demonstrate our ability to deal with the vast and urgent problem of waste-land rehabilitation, scientifically and economically. Unfortunately, with all the talk of the evils of soil-erosion and of the necessity of reclamation of waste-land—the wherewithal is not yet available and what little is being done is made possible through sheer personal efforts amidst the heart-breaking circumstances of lack of funds and appreciation.

The first divisional forest officer in Dhalbhum division was Mr. Hardayal Singh. Although he was up to his neck in the arduous organisational work, his devotion to duty made time for him to start reforestation work in a small way. He was however handicapped by still greater paucity of funds than now and also went on leave after less than two years' work. I joined in September 1938 (and continued, with short periods of absence on leave or temporary transfer, till April 1946). There was no regular scheme of reforestation but a small amount used to be provided for in the budget mainly for filling in blanks in the

worked out coppice coupes. Concentrated reforestation work was started accidentally and experimentally but it gradually developed and has now been put into a regular scheme.

One day, while inspecting the Kesarda coppice felling series, I noticed a stretch of bare land on the outskirts of the forest and close to the village. Such bare helpless lands always make me think. This one was about 30 acres in area and completely devoid of vegetation. The soil was baked brown and hard, almost as hard as cement floor. Not a blade of grass grew though the heavens poured. It was thoroughly sheet-eroded and in parts also gullied. An idea of the condition of the bare land will be available from *Fig. I, plate* 1. The sight was despairing enough but it would be a damaging discredit to the department if we could do nothing to reclaim and utilise such waste lands in our charge. Finding that in the neighbouring villages bamboo groves were flourishing I decided to try bamboos here. Bamboo is also in great demand in the locality, for timber not being available and firewood scarce, bamboo to an extent fills the bowl. It is also much sought after by the paper mills since this area is closer to the Bengal group of paper mills than any other forest area in Bihar. The average distance to the railhead is about 15 miles and Calcutta is 114 miles therefrom. Jamshedpur, as a great potential consuming centre, is only 40 miles away.

In 1939 I started bamboo plantation. The species used was *Bambusa nutans*, growing commonly in the villages around. With the meagre funds available, 1,695 rhizomes were planted (covering about 17 acres). Planting was done between the 30th June and 8th July. Some rhizomes had to be carted from Dudhkundi, 10 miles away, as the total requirements were not available in the neighbourhood. By the end of September, 793 rhizomes had died and towards the end of the following summer the casualty totalled 1,109. Casualty percentage 65. The devil of the soil had taken his toll.

Study of the technique adopted by the villagers and consultation with village elders taught me more than I could learn from text books. The following year I employed a revised technique. Plantation was started on the 2nd June, 1940, nearly a month earlier than before. (Seven rhizomes were planted as early as the 11th May 1940 and they yielded a very good result). Success this year was 95 per cent.

The principal mistake that we had made in the first year was in respect of the time of planting. Bamboo must be planted well in advance of the break of the monsoon. It should be done at the time of *rohan* (about the end of May), when villagers scatter paddy seed in their fields. Then the rhizomes get moist heat which is essential for their development. Other defects of the first year's plantation were :—(*i*) the rhizomes suffered from exposure in transport by cart from 10 miles distance; (*ii*) the rhizomes lay in the sun until planted; (*iii*) sufficient care was not taken in digging up rhizomes in a manner so that the buds be not damaged.

As a result of experience gathered from trials and errors the following standard planting rules have been framed by me. These invariably yield very good results :—

"Spacing 22 ft. x 22 ft. This was empirically adopted but *has* proved itself suitable.

Pits 15 inches in diameter and 12 inches in depth should be dug and kept ready at least 2 months ahead of the planting time. This is advisable in order to condition the soil.

Rhizomes are obtained from the neighbouring villages. Take care that the rhizomes are properly dug up, that the buds are not damaged. Of the stem retain 6 ft. to 8 ft. length and cut away the rest. Prune the branches.

Planting time is the most important. Bamboo plantation must be done at the very first shower of rain following summer, at the commencement of *rohan*, when villagers scatter paddy in their fields. A week or ten days earlier is good, a week or ten days later is harmful. Plantation after the rains have well set in yields poor results and the mortality is higher.

Put two pitchers of water into each pit. Water may have to be brought from a distance but the result is well worth the cost. If the water of the first shower has collected in a nearby ditch, that will come in handy. Put back a portion of the dug-up earth into the pit and make puddle. Plant the rhizome in the puddle keeping the stem straight. Then put back the rest of the dug-up earth and press hard. This pressing hard is also important

The stem must not be loose, otherwise the wind will shake it and disturb the rootlets and thereby kill the rhizome.

The water decanted into the planting pit keeps the rhizome alive and helps it to throw out rootlets. It has been found to keep alive for a fortnight though no rain fell after the planting date and the sun blazed fiercely throughout. If a longer rainless period intervenes (which it once did in 1942 but is rare) watering once will be necessary—two kerosene tins of water to each rhizome.

Rhizomes in transport from the village clump to the planting site must be suitably protected from exposure to sun. While it waits to be planted, keep it in puddled mud in a ditch nearby under shade.

Putting more earth round the base should not be done otherwise the root system gets raised to the point where the earth touches the highest node and the uplifted clumps are in danger of being blown down during a storm.

In the year prior to planting it is good to plough up the land and sow it to *boga* (*Boga medeloa*). This is essential if the land is hard and much eroded.

Fencing round the plantation is essential. No plantation is worth the cost and trouble without adequate fencing. The fencing that has been found best in this area is the trench fencing, 6 ft. wide and 4 ft. deep, with the earth thrown up inside in the shape of a *bundh*. (*See Fig. II, plate* 1.)

It is also the local belief that the rhizome when planted should have the same orientation as in the mother clump. To ensure this we mark the north on the stem with a notch, and when planting keep the notch towards the north.

Another local custom is to throw in a pinch of paddy into the puddle before planting the rhizome. The principle of this too is not more known than is the ghost, but we have thoroughly succumbed to it. And when the Brahmin forester ceremoniously sits by the planting pit and thoughtfully scatters the pinch of paddy while the women coolies stand around with pitchers of water, it completes the picture of a dark ritual.

Regarding the ploughing up prior to plantation the idea came as follows :—It was noticed after the 1939 and 1940 plantations in Kesarda that the highest mortality lay in the patches of hardest soil though the planting pits had been prepared equally well. Row after row of rhizomes were found dead. Replacements met no better fate. The land in between the rows was then ploughed up and *boga* was sown. This caused appreciable improvement to the crop.

The planting time cannot be too much stressed. This is the key to success in bamboo plantation. I begin my bamboo plantation in the last week of May and complete it by the middle of June at the latest but usually by the end of first week. During this period one or two showers fall but the heat is intense. This moist heat is vitally important.

A word on the trench fencing. I had no scheme or design of fencing in the beginning. It evolved itself by degrees. It originated in Narsingarh plantation. This plantation like others was not fenced at that time. It being very close to the village, people used to dirty it to an unbearable degree. Warnings and notices proved useless. Grazing was of course already a baffling problem but the filth cliched the issue. On a spur of temper I ordered a ditch, 8 feet deep and 6 ft. wide, to be dug over a length to prevent people from entering the plantation. As the work progressed we found that such big dimensions were not necessary for the purpose so we came down to the size 5 ft. wide and 3 ft. deep. This proved effective against men and cattle. The idea then came, why not take the trench all round the plantation so that nothing might enter from any side ? And the Narsingarh plantation was thus fenced.

Then the idea progressed, why not similarly fence the other plantations ? And we came to Kesarda. A trench of 5 ft. x 3 ft. was dug around the 30-acre plot, length 52½ chains.

This enraged the neighbouring villagers for their cattle could no longer enter stealthily and graze as they had been doing hitherto, so they undertook the mission of driving and collecting stray bulls from distant villages. These ownerless bulls alone could beat us for no kine house would agree to impound them. Having brought them to the verge of the trench fencing they urged these unwilling bulls forward by coaxing, by threatening, by catcalls and by beating. The brutes having no way of escape jumped the trench. When this report reached me I pondered like the outwitted commander and ordered the width to

be increased to 6 ft. and the depth to 4 ft. And now no bull can jump across, however hard pressed.

On the top of the fencing *bundh* I have planted *sissoo* (*Dalbergia sissoo*), and *Kathal* (*Artocarpus integrifolia*). The *sissoo* particularly is growing splendidly and will by itself repay the cost in due course. On the inner slopes *sabai* grass (*Eulaliopsis binata*) has been planted. The growth is phenomenal, and from the second year onwards a small revenue from the *sabai* has been coming in. On the outer slope aloe has been planted in two horizontal lines. This will spread and make a matty barrier and will serve as the second line of defence.

The cost of trench-fencing actuall ncurre as follows :—

Narsingarh	52 chains	Rs. 280 (10 acres.)
Kesarda—	250 chains	Rs. 1,138 (121 acres in two blocks of 30 and 91 acres respectively).

It works out to Rs. 376 per mile or Rs. 11 per acre on the prewar wage rate. If the area be more compact the cost per acre will be less. At this price no other comparable fencing can be made. The trench fencing is in addition more effective and lasting. It is of course most suitable in plain or gently rolling country but if it is made on the contour principle it can well be used in fencing isolated hillocks, as has actually been done by me in the case of the Nandup hills near Jamshedpur.

When sufficient experience had been gathered I drew up a 15 year reforestation scheme commencing from 1942-43. It has been sanctioned by goverament. The area to be covered is 1,206 acres as follows. It is situated in five different localities. Till now the work of reforesting flat denuded land has been concentrated in three localities, namely, Dudhkundi, Ke arda, and Narsingarh.

be nted with tree species		781 acre
„ „	bamboos	241 „
„ „	*sabai*	184 „
		1,206 acres.

The work done up to 1945-46 on flat denuded nd at Narsingarh, Kesarda and Dudhkundi together with the , is as follow

Planted up with	*Cost*
(1) Tree species—	
(a) stump planting	15 a s Rs. 180/- R. 12/- per acre.
) broadcast sc	75 acres. Rs. 372/- or Rs. 5/- per acre.
(2) Bamboos	.. 82 acres—R. 2458/- or Rs. 30/- per acre or -/5/- per clump.*
(3) *Sabai*	.. 26 acres—Rs. 808/- or Rs. 31/- per acre.
Total	.. 198 acres

*True cost in prewar days was -/2-/ per clump as follows:— Cost of rhizome -/1/-, digging and transport -/-/6-, digging pits -/-/3, planting, etc. -/-/3. At present the cost is -/8/- per clump.

Both at Kesarda and Dudhkundi contour trenches had to be built in places where the slope and the soil demanded that to improve moisture content and to prevent soil erosion no water should be allowed to run away. Several small dams had to be built across gullies or *nalas* to reclaim the eroded land. The cost of these works is not included in the foregoing.

The total cost incurred up to 1945-46 for doing the 198 acres plantation (excluding trench fencing) is Rs. 4,754 or Rs. 24 per acre. Including fencing the average cost per acre is Rs. 35.

On the technique of reforestation of flat bare land with trees a few notes may be added :—

Stump planting was the method hitherto employed. This of course had given good results. But the defect with this system, apart from the higher cost, was that the maximum area that could be reforested with trees in any one year was limited by the number of stumps available from the nurseries. I therefore adopted the method of twice ploughing up the land and broadcast sowing with seeds of *piasal* (*Pterocarpus marsupium*) and *gamhar* (Gmelina-*arborea*) mixed with *boga*. The *piasal* and *gamhar* germinated quite promisingly but by the following summer almost all disappeared causing great despair, and I feared they had all died out. But to my agreeable surprise all the seedlings that had disappeared shot up vigorously again the following rains and survived. Weeding for the first two or three years is necessary. The growth of *piasal* and *gamhar* in broadcast sowing is very encouraging and although inferior to that in the stump plantation, it is good enough for the cost and labour (*vide Fig. I, plate* 2).

Fig. I.

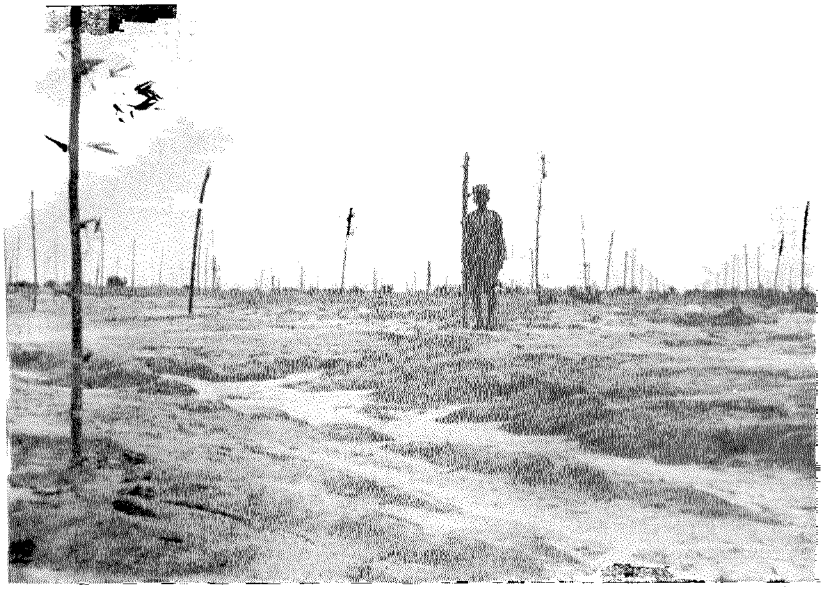


Photo: J. N. Sinha

The original area at Kesarda taken up for bamboo plantation—Rhizomes planted in 1939.

Photo: J. N. Sinha

Fig. II.

The trench fencing. The photo was taken at Nandup hill, but the same kind of trench fencing has been made on the flat land.

Fig. I.

Photo: J. N. Sinha

Dense crop of **piasal (Pterocarpus marsupium)** saplings grown from the broadcast sowings after ploughing. (Sown July 1939, photo October 1945, Dudhkundi).

Photo: J. N. Sinha.

Fig. II.

A full grown average size clump (planted July, 1939, photo October, 1945). Ranger Nurul Haque is holding the parent rhizome which is now dry and dead (Kesarda).

These two species have been found to be the most successful. *Boga* acts as nurse and shelter and is useful specially in such poor lands.

The patch of land broadcast sown with *piasal* in 1939 has grown into a beautiful *piasal* forest. The average height is 15 ft. and some of the plants are over 25 ft. in height. Most of the stems are good and healthy and there are plenty to spare for thinning. Where so much success can be obtained with broadcast sowing, this is undoubtedly the best method. In broadcast sowing we mix other seeds also, like *neem* (*Melia Indica*), *kusum* (*Schlichera trijuga*) or *simul* (*Bobmax malabaricum*). These also grow here and there but my main crop is formed of *piasal* and *gamhar*.

The limitation to the rate of progress of reforesting flat denuded land is imposed by the lack of means at present to plough up sufficiently large areas in one year. We have to depend upon the ploughs of local agriculturists.

Unfortunately, our needs clash; I need their ploughs exactly when they need themselves. And without thorough ploughing nothing can be done on these hard eroded lands. For plantation of bamboos, or *sabai* or broadcast sowing of the tree seeds, or anything, ploughing is to this hard eroded land what milk is to the infant. If we have tractors and mechanical contour ridgers we can deal with really large areas. Extension of bamboo plantation may be limited by availability of rhizomes, but *sabai* can be extended more rapidly and for broadcast sowing of *piasal* and *gamhar* there is no theoretical limit as any quantities of seeds may be collected from the forest. The backbone of this type of reforestation work, I may be permitted to repeat, is the means to plough up well and deeply a sufficiently large stretch of land every year and mechanical means to build contour ridges. If the Dhalbhum division is supplied with these mechanical appliances along with sufficient funds, the dead and dumb expanses will soon be alive and singing.

Reverting to the bamboo plantation, another departure from the general technique followed so far in Bihar (one being the time of plantation) is in the size of the stem attached to the planting rhizomes. Two to three feet has been the usual size used so far in Bihar. Mortality has generally been high in bamboo plantations hitherto attempted and the smallness of the stem may be one of the causes. Our size in Dhalbhum is 6 ft. to 8 ft. The possible reason why 6 ft. to 8 ft. stem is better than 2 ft.—3 ft. may be this. On the rhizome being planted the roots catch the soil and with the reserve food stored therein send up fresh leaves at the nodes. In favourable conditions one or two culms are sent up by the end of the rainy season the same year. In unfavourable conditions only the leaves at the nodes come out. These leaves manufacture food for the root and replenish that which was spent out of the reserve. This also enables the roots to grow and expand. Naturally therefore if the nodes are too few, the total leaf surface and therefore the total food manufacturing capacity is too small. The rhizome with a small stem will not be able to stand against adverse conditions whereas the one with longer stem has greater chances.

It has been observed that in about 50 per cent cases one new culm comes out of the rhizome the same year. In very favourable conditions even two come out. The following year during the rains two to four are added. In adverse conditions for two or three years not a single new culm grows. The parent rhizome has been noticed to struggle up to 5 years before sending up one thin culm, while its contemporary on better soil has grown into a decent clump by then. Thicker and longer new culms emerge from the ground as the clump grows in age.

Present and Future

The 30 acre bamboo patch in Kesarda is now 6 years old and ready for exploitation (*vide Fig. II, plate.* 2). The number of culms per clump varies from 5 or 6 to about 25. The average number is about 12. The height is 25 ft. on the average and the girth, 10 inches. I expect 4 culms per clump on the average to be available for the first cutting. The culms to be removed at this first cutting are naturally thin and short. The total output, there being 100 clumps per acre, will be $3,000 \times 4 = 12,000$. culms. The present market rate for good thick bamboos is 2 to 3 for a rupee. The thin bamboos are expected to sell about 12 for a rupee. The first yield will thus be of Rs. 1,000.

At the next cutting after three years and in subsequent cuttings at least 8 bamboos per clump on the average will be available

for exploitation; total 24,000. Even counting 6 for a rupee (seeing that the present price may fall) the revenue will be Rs. 4,000. That is to say, a sustained revenue of Rs. $\frac{4000}{30 \times 3}$ or Rs. 44 per acre per annum from the bamboo plantation is assured. Compare this with Rs. 41 per acre as the cost of plantation including fencing with little recurring expenditure.

Sabai has so far cost Rs. 31 per acre to plant excluding Rs. 11 per acre being cost of trench-fencing. This is rather high, the reason being that *sabai* is in short supply in this locality. Now that we have already grown 26 acres of *sabai*. we shall draw upon it for extension of our plantation and the cost will be reduced. I expect that *sabai* plantation eventually will not cost more than Rs. 15 per acre or Rs. 26 including fencing. As against it the revenue obtained in Kolhan division from *sabai* plantation is Rs. 47 per acre *per annum*.

The above figures show how profitable, e\ financially, it is to plant up the waste lands Dhalbhum and of Chota Nagpur generally w *bamboo and sabai.) These two comm*ities are very much in demand. It is suc colossal national loss to leave these large st ches of dismal barren eroded land in their p sent condition. The soil is further deteric ting and the denuded land is adding to the fl menace. The waste land in its present c dition is altogether useless from the cultivat point of view, and yet, as the figures sh reforestation can produce out of it substan financial profit comparable to the profit fr agriculture.

The vast denuded lands shout for our att tion. The local population look to us for tim and firewood. The cattle helplessly ask fodder.

Let a bold national policy answer prayer.

ANTI-EROSION WORK IN KALIMPONG FOREST DIVISION *

By S. K. Basu

(Deputy Conservator of Forests, Kalimpong, Bengal)

Kalimpong forest division is situated in the Eastern Himalayas between 26° 51′ and 27° 12′ north latitude and between 88° 28′ and 88° 56′ east longitude. It is bounded on the north by the Tista river and by a demarcated line beyond which lie the States of Sikkim and Bhutan, on the west by the Tista river on the east by the Jaldaca river beyond which lies Bhutan State, and on the south by the common boundary of Jalpaiguri district where the foothills of the Himalayas meet the plains.

It is a mountainous region, the elevation being 10,400 ft. at the highest point going down to above 500 ft. where the hills meet the plains . The rainfall varies in different localities but is rarely less than 150 inches in the year. In the eastern part, the annual rainfall is over 400 inches.

The margins and centre of this region are covered with reserve forests, while included within the forests are *khasmahal* areas given over to cultivation, under the civil department.

Owing to the general geological featu of the country, the grouud is peculiarly lia to erosion. The general slopes of ground is also very steep, rarely less than inclination to the horizon of about 4 Everywhere outside the reserve forests, tivation takes place with little or no consid tion to the dangers of erosion. The resul all these factors is that, wherever the l is not covered with forests, the soil has aln all disappeared and deep gullies and la landslides are occurring in many pla *Report on the landslides of the Kalimp division* by E. R. Gee).

Two such areas have been handed over the forest department for "protection". may be stated at the outset that in no have the boundaries of the areas han over been approved by the forest departm In order that adequate protective meas can be taken it is obvious that the *whole* of

*Paper read at the Seventh Silvicultural Conference (1946), Dehra Dun, on item 4—contour bunding and tren as counter erosion measures.

area actually covered by the landslides and gullies together with sufficient land in their heads and margins should be protected. Owing to reasons into which I need not enter, the civil authorities have not found it possible to transfer areas on this rational basis. In the case of the large Dolepchan Slip the bottom half of the slip where the deepest gullies are, have not been transferd to the forest department and actually wet cultivation is going on up to the margins of the gullies and in every small patch where cultivation is yet possible.

The areas handed over are both underlain by the geological formation known as Sikkim Gneiss. This series consists here of well joined quartizitic gneisses which include thin intercations of mica schists occurring at short intervals parallel to the bedding. These mica schists are easily disintegrated and landslides are the result.

The two areas handed over are briefly described below :—

(1) THE DOLEPCHAN SLIP.—Parallel to the Tista river which forms the western boundry of the Kalimpong region, runs a spur from north to south. The western slopes of this spur drain into the Tista river and the eastern slopes into its tributary the Rilli. The town of Kalimpong lies on this spur where its elevation is 4,000 to 4,500 ft. The spur rises higher towards the north carrying, a little below the top of it, the Kalimpong-Algarah road which is an important highway carrying as it does the greater part of the wool traffic from Tibet.

About 4 miles north of Kalimpong in this spur, a very large landslip is gradually formed on its eastern slope in the Dolepchan *khasmahal*. The slip now extends from the top of the spur (elevation about 5,000 ft.) down to the Rilli river (about 2,200 ft.).

Two steep gullies extend from near the top coalescing downwards a little below the Kalimpong Algarah road into a single deep gully reaching down to the Rilli river. The steepness of the gullies can be imagined from the fact that the depth of the gullies from the margins is often more than 150 ft.

It happened that owing to the landslides occurring in the place, the C. & W. department had to spend about Rs. 4,000 per year for repairs to the Kalimpong Algarah road on this spot alone. This is the reason why about 190 acres, comprising the top part alone of the slip extending to some distance above and below the road, were handed over to the forest department "for protection". The lower part of the slip where the deepest gullies are situated are not easily visible from the road and these were excluded from the area handed over as were also excluded the land up to the very margin of the gullies even on the top part, the revenue department being still able to obtain some rent from cultivation of the land extending to the margins of the gullies, although, of course the margin is all the time receding owing to the inevitable extension of the gullies.

(2) KALIMPONG DEVELOPMENT AREA.—A part of the spur south of the market of Kalimpong has been taken out of the *khasmahal* and is being 'developed' into a residental area. It was found that portions of the area were very unstable where slips and gullies were occurring. Small patches of land within this area have been separated out and handed over to the forest department "for protection". From the point of view of the forest department, these small patches each measuring from over 20 acres down to less than one acre in extent are useful for studying anti-erosion work on a small scale. The gullies here are not so deep as in the Dolepchan area but some of them are as much as 50 ft. or more in depth.

Work in the Dolepchan Slip started from 1938. In the Development area, work started regularly in 1942.

A few facts which have been learnt by actual experience in this work are given below (in the style of Polonius!) in the hope that they may be of some help when similar work is undertaken in future.

Protection of the Area

The first step necessary is to protect the area from trespass by men and animals. Removal of every kind of forest produce must be absolutely prohibited. The rainfall here is heavy during the rainy season and even when rain is not actually falling at that time, the air is humid. The temperature is also not too cold. So that, given adequate protection,

plenty of grasses, weeds, and small seedlings of shrubs and trees start growing almost immediately. These are extremely useful. In the latter part of the dry season, *i.e.*, from February to April there is scarcity of fodder and unless adequate steps are taken, "fodder" *i.e.*, all vegetable growth, is bound to be removed illicitly. Strict protection is necessary. Goats and cattle do damage not only by browsing but also by loosening the soil by their hooves. Demarcation and fencing are therefore essential. These enable the villagers to know the boundaries of the areas protected (these boundaries are anything but straight!) so that any one doing illicit action within the areas may safely be presumed to be doing so with criminal intention. The fencing, to keep off goats and cattle, may be of two strands of barbed wire only. The area being surrounded by population, will be necessary to allow a sufficient number of paths and roads through the areas, entry being afforded preferably by stiles. Otherwise it will be practically inpossible to maintain the fencing. Besides, the more contour roads there are the better as they act as a sort of terracing. Also for obvious reasons, every encouragement should be given for water to be carried away from the springs in the area either in pitchers or by pipes connected to reservoirs. Irrigation drains may be allowed provided they are underlain by well built stones so that there is no percolation underneath.

The areas to be protected in these cases are actually the gullies themsevles and quick results are desired. Afforestation by itself is therefore not likely to be immediately successful without engineering works. Something must be done to hold up the soil until the trees can grow up and start manufacturing their own soil and furnish a protective covering to the ground below.

Engineering Works

For engineering works, the first step necessary is to study the ground carefully and plan a layout of check dams and contour drains. In the main or deepest gully, it is essential to have a series of well and strongly built check dams or retaining walls of stone masonry, extending from top to bottom, where the gullies are so deep as in Kalimpong. The height of the dams may be anything from 4 ft. to 10 ft. above the ground. The foundations should go down at least 3 ft. below the surface and the flanks should be well embedded in the sides of the gullies. It is essential to have a spill-way over the middle of the dam, the spill-way being about a foot or two below the height of the dam in the flanks. The lower side of the dam should be stepped down and a soling of flat stones should be provided at the bottom of the dam extending to at least 4 feet below the dam.

The horizontal distance from the base of one dam to the top of the nest lower one may be about the same as the height of the upper dam.

Where the sides of the gully are of loose crumbling rock, contour drains built along such a bank with a light gradient towards it should next be laid out. The bottom surface of these drains must be of impermeable stone. In Kalimpong, series of contour drains following one below the other at varying distances, built of stones, with a V-shaped cross section have been found to be extremely useful to hold up the ground where the bank is almost (though not quite) vertical and the soil just sufficiently strong enough to retain the drain.

In the sides of the main gullies and in the beds of the branch and smaller gullies, large numbers of small check dams must be constructed but these may be of a more or less temporary nature and may be constructed of a variety of materials depending on what substance is most easily and cheaply procured on the spot, such as, loose rubble (coursed or uncoursed), or of brushwood. The uprights may be of bamboo or small poles or branches or rejected sawn timber, etc. The horizontals are brushwood or swan slabs or bamboos, etc. Fascines made of bundles of a commonly growing shrub *Artemisia vulgaris* or of thatch grass are very useful for this purpose; bamboo mats, or old C. I. sheets if they ever again become cheap, can also be used.

Check dams of such temporary materials are often sufficient to hold up the soil for two or

three years by which time the ground may be at least partly stabilised. Even if they are carried down during the next rains they would generally have been found to have done some benefit and they can be renewed without much expense. All check dams should have some slips of quick rooting species such as *Erythrina* or grasses or bamboos planted on top of them.

Cracks on the surface of the ground will often be found sometimes only 2 or 3 feet long each, sometimes extending to 200 or 300 yards or even more. During the next rains, water percolates into these cracks and the result is a subsidence. Often these cracks or series of cracks extend all round the heads of the gullies sometimes at a distance of even 20 or 50 feet away from the margins. The subsidence may be into the gully in severe cases or just 2 or 3 feet. It is necessary to have men patrolling and looking for these cracks which are often hidden among the grass, and earth and stones should be pressed down into them.

Wherever the ground is not steeper than about 45°, it is useful to terrace it and sow seeds or plant on the terraces. The terraces should have ridges on their outer sides, or have gentle inward slopes. Even on steeper ground, sowing of seeds of *Alnus nepalensis* and *Betula cylindrostachys* in shallow furrows have been found useful. They germinate and then their shoots die back year after year, but provided the ground has not slipped down in the meantime, a fairly good percentage manages to come up eventually.

On bare ground where a landslide has recently occurred, seedlings either planted or germinated from seed usually die down in the dry season owing to the great heat of the bare rock or soil. Sometimes as stated above, they eventually get themselves established after several years. A trial is being made this year of sowing seeds in such a place in shaded field nurseries to see whether seedlings grown this way can grow up without dying back. Incidentally, in such a case it would be necessary to ensure that the ground would be sufficiently stabilised to support the plants when they grow up. The soil will not only have to support the weight of the trees but must also withstand the leverage exerted by the winds blowing on their crowns.

Choice of Plant

A few notes about the choice of plants for covering the ground are given below, although it must be obvious that any plants that we can get to grow in such an area or that come in naturally are useful in some measure.

To begin with the grasses. In general, while grasses are most useful for binding the soil with their roots, trees, shrubs and even herbs and weeds are more useful to manufacture a soil covering. Thatch grass well protects the soil just below it, but in a heavy shower of rain, it cannot check the rush of water which just flows down over them. Unless, however, an area covered by thatch grass is being planted up with trees, each year's growth should not be allowed to be cut away but they should be left to form a tangled mass gradually.

Clumps of the Giant Star grass (*Cynodon plctostachyum*) were obtained from Almora and planted but although their growth lengthwise was good, local grasses were found more satisfactory in respect of branching and bushiness.

Of the small bamboos, a tufted *Arundinaria*(?) locally known as *amlisho* which grows in thick clumps and takes root quickly is most useful for binding new landslides. *Bambusa nutans* can also grow in new soil but it takes about three years to establish itself and start throwing up new shoots. *Melocanna bambusioides* is also being tried.

Of trees and bushes, given adequate protection from "fodder" cutters, and grazing, the following species come up naturally in three or four years' time but artificially they are difficult to grow and slow to establish: namely *Maesa montana*, *Maesa macrophylla*, *Engelardtia spicata* and *Schima wallichii*.

As there is little fertility in the soil, at least 40 per cent. of all plants put out may be expected to die each year and refilling of vacancies must proceed for at least 4 or 5 years, sometimes more.

The hardiest and quickest growing species of trees are firstly, *Alnus nepalensis* and secondly, *Betula cylindrostachys*. Some of the former put out in the Development area in 1943 are already over 25 feet high. Their roots are also said to contain nitrifying bacteria and are therefore useful for fertilising the soil. *Cryptomeria japonica* is another most useful plant for covering unfertile ground. For use on grassland, I believe it has no equal.

It has a good survival percentage and although slow for the first two or three years, its subsequent growth is rapid. Other useful plants to grow on unfertile soil are *Bucklandia populnea* and *Cupressus cashmeriana*. Branch cuttings, as much as 5 or 6 feet high, of *Erythrina* spp. can strike root on bare landslides. Thousands of them have been planted and quite a fair percentage have struck root. Their drawback is that their output of leaves is small and they are leafless for several months in the year.

The above mentioned species have so far proved most successful. But experiments are being made with a large number of other species and of them the following appear to be most promising: *Macaranga denticulata*, *Croton tiglium* and *Michelia lanuginosa*.

A NEW SPECIES FROM ASSAM

Mansonia Dipikae C.S.Purkayastha Sp. Nov. *Family*—Stercuiaceae

Vernacular Names:—*Badam* (Assamese); *lapse* (Nepali)

Mansonia dipikae C.S.Purkayastha spec. nov: *M.altissimae* A. Chev. proxiss'ma sed ab ea inflorescentia minore, penduncul o breviore, pedicellis longioribus, bracteis absentibus, follis glabris et basi pedicellorum glandula magna satis recedit.

A large evergreen tree, attaining 25-35m. in height and girth up to 3m.; bark greyish white with longitudinal fissures. *Leaves* petoiled, simple, softly tomentose with stellate hairs when young, but ultimately almost glabrous, 15-25 cm. long and 8-13 cm. broad, variable in shape, ovate-lanceolate, oblong or obovate-oblong, shortly acuminate, crenulate-denticulate, cordate at base, 5-7 nerved at the base with about 5 pairs of lateral nerves; petiole 3.5-5 cm. long. *Stipules* small, deciduous. *Inflorescence* a short panicle, terminal with the lower cymes axillary, densely tomentose with stellate hairs, 5-7 cm. long and as broad; main rachis about 4 cm. long; pedicels 7-13 mm. long with a large gland at the base; bracts absent. *Flowers* about 2 cm. in diameter. *Calyx* spathaceous, unequally split at the tip, densely tomentose outside with stellate hairs 12-13 cm. long. *Petals* 5, free, obovate, densely tomentose outside near the base, 15 mm. long, white with reddish tinge towards the base. *Ardrogynophore* 5-6 mm. long, tomentose; *Stamens* 10 in 5 pairs, each pair alternating with a staminode; anthers filamented about 2.5 mm. long, dorsifixed; *Staminodes* 5, linear-spathulate. *Ovary* of 5 free carpels densely tomentose; styles linear; ovule 1 in each carpel. *Ripe carpels* (1-5) of stellately spreading samaras, wings obliquely obovate--oblanceolate (*See oppcsite page*).

Common in the Dhansiri reserve of Nowgong and Rangapahar reserve of Naga Hills district. Altitude—500-700 ft. Flowers June-July. Ripe fruits—October-November.

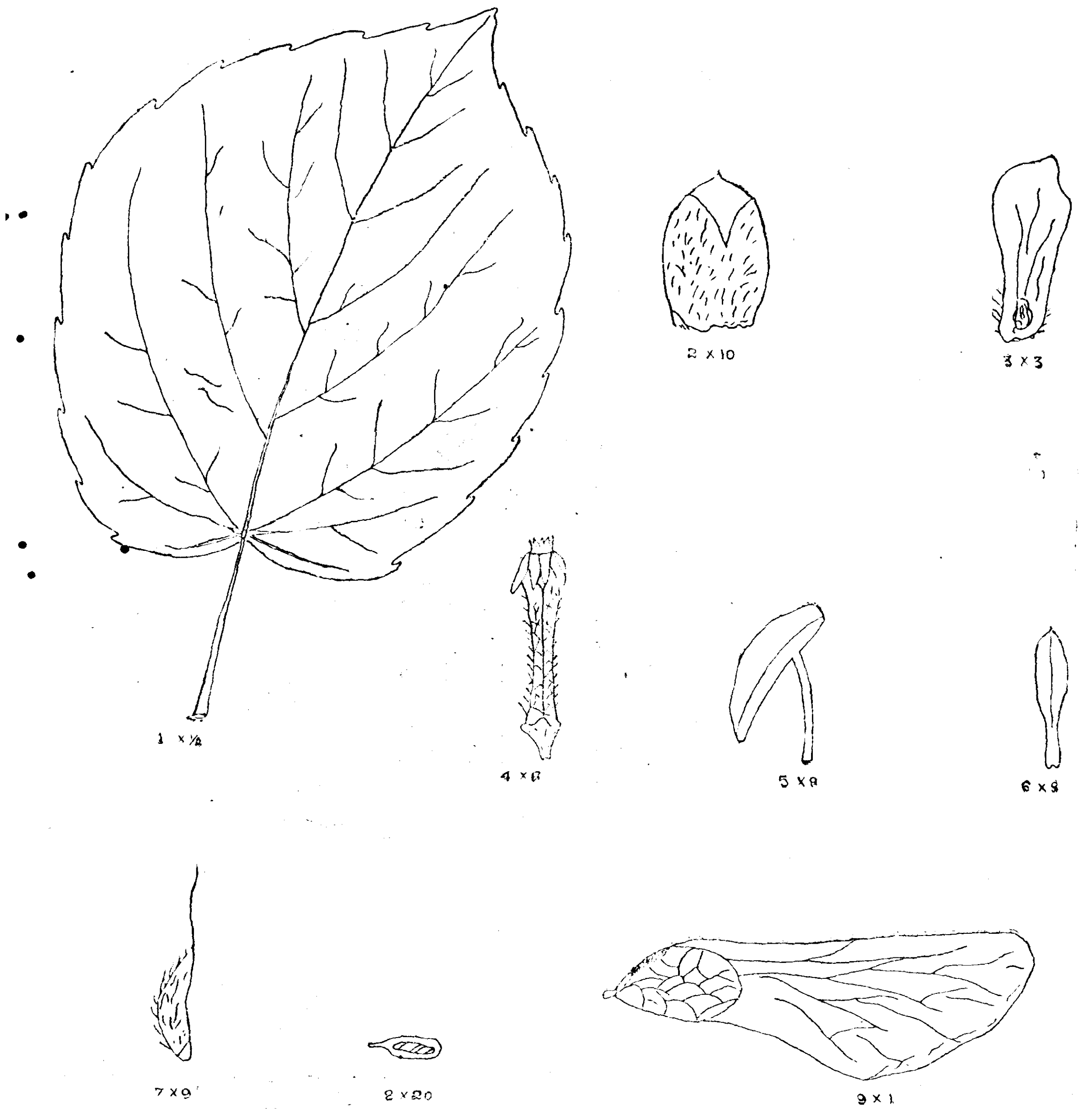
One fruiting specimen has been sent to the herbarium, Lloyds botanical garden, Darjeeling, another to the herbarium, forest research institute, Dehra Dun, and the type specimen is in the forest herbarium, Shillong.

The species has some similarity with *Mansonia altissima* A.Chev., known to occur only in West Africa, but the points of difference are; smaller inflorescence, shorter peduncle, longer pedicels, bracts absent, presence of a large gland at the base of the padicels and glabrous leaf.

This is a good timber tree, with a durable heartwood and takes a good polish. The timber has been found suitable for boot last and is likely to prove a good timber for bobbins. The following figures show the comparative strength of this species in relation to teak:

Species	Weight per cubic ft. lbs.	Static Bending.		Impact Bending.		Hardness.		
		Fibre stress at elastic limit (lbs. per sq. in.).	Modulus of elasticity (1,000 lbs. per sq. in.).	Fibre stress at elastic limit. (lbs. per sq. in.).	Modulus of elasticity (1,000 lbs. per sq. in.).	Radial (lbs. per sq. in.).	Tangential (lbs. per sq. in.).	End. (lbs. per sq. in.).
Teak (Airdry) (Burma and Malbar)	34	10,815	1,877	19,460	2,434	1,160	1,145	1,105.
Mansonia Dipikae (Kiln d y)	42	10,815	1,853	21,585	2,979	1,350	1,360	1,360

The author acknowledges with thanks the assistance given by Mr. M.B. Raizada and Dr. K.A. Chowdhury of the Forest Research Institute, Dehra Dun, and Dr. K.S. Mukerjee of the Lloyd Botanic Garden. Darjeeling, who took considerable pains in proper scrutiny and diagnosis of this new species. Thanks are also due to Mr. V.D. Limaye of the F.R.I. for carrying out the strength tests of this timber and supplying the necessary data which accompany this paper.



MANSONIA DIPIKAE C.S.PURKAYASTHA.

1. Leaf, 2. Calyx, 3. Petal, 4. Androgynophore, 5. Stamens, 6. Staminodes, 7. Carpel, 8. Cross-section of the carpel with solitary ovule, 9. Fruit.

THE SEVENTH ALL-INDIA SILVICULTURAL CONFERENCE

BY A. L. GRIFFITH, D.SC.

(Secretary of the Conference)

(Dehra Dun, October 28th to November 6th, 1946)

The seventh silvicultural conference has just concluded. It was the first full scale conference to be held since 1939 although readers will remember the sixth conference held in 1945 which was a short conference of the provinces to endeavour to ascertain the effects of the war on silviculture and forestry in general and to re-establish the personal contacts that had been unavoidably lost under war conditions. (*vide Indian Forester* 71(6) P. 187).

This seventh conference has been unique in Indian silviculture in several ways. It was the most representative that we have ever held and was attended by 51 delegates, representing all the Provinces, the Forest Research Institute and 20 of the larger Indian States or groups of States (*plate* 3). Some 35 subjects for discussion were originally listed and the 16 actually discussed were chosen by a majority vote. The resolutions passed and the reasons for those resolutions which are listed below, when compared with previous conferences show the effects of the war and the general trend in forestry in the past decade—a swing over from the problems of the heavy timber forests to those of the marginal lands and the dry and arid areas. The vast depletion of India's fuel supplies caused by the war was also a salient feature. The seventh conference was also unique in that for the first time we had Ceylon's silviculturist with us and we hope that in future conferences contacts with other interested neighbouring countries will be made.

During the conference, tours were made round the various branches of the Forest Research Institute and round the Experimental Garden and Demonstration Area of the Central Silviculturist. Delegates were also shown the Doon forests and the effect the war had on them by Mr. Haq, the D.F.O. Dehra Dun, to whom we extend our cordial thanks for the trouble he took for us.

It must however be emphasised that the resolutions given below have not yet been commented on or accepted by any higher authority.

Resolutions of the Seventh Silvicultural Conference Held at Dehra Dun, from the 28th October to the 6th of November, 1946

GENERAL RESOLUTION.

(Drafted by a Committee of all representatives from Indian States and the Silviculturist, Ceylon).

In view of the fact that Forestry in many of its most important aspects transcends all political boundaries, this conference resolves that in all resolutions passed on any item of its agenda, wherever "Provinces and States" are mentioned, this should be taken to include Ceylon and neighbouring countries who may wish to co-operate.

Note :—In the Proceedings where the word "Provinces" occurs alone, the words "Provinces and States" should be substituted wherever this is not repugnant to the context.

ITEM 1. THE ORGANISATION OF POST WAR SILVICULTURAL RESEARCH.

Committee.—

Mr. Raynor (U.P.) (*Chairman*).
Mr. Garland (Sind).
Dr. Griffith (F.R.I.)
Mr. Ford Robertson (U.P.).
R. B. Raghavan (Madras).

States Sub-Committee.—

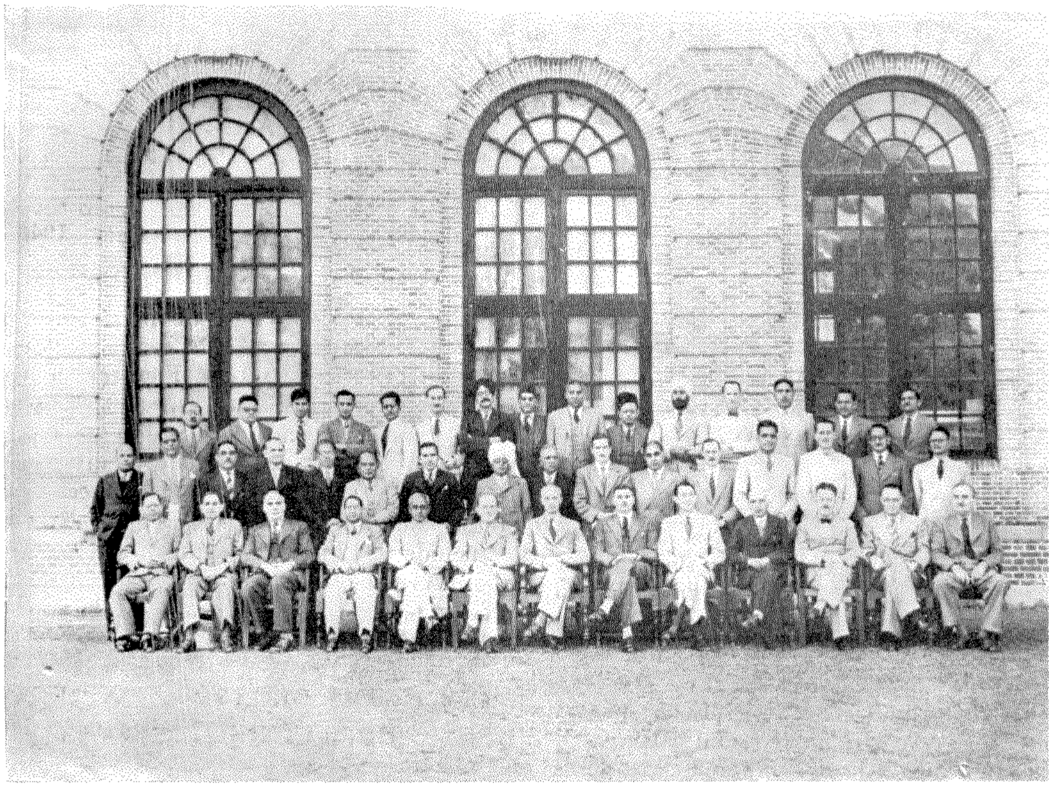
Mr. H. F. Mooney (Eastern States) (*Chairman*).
Mr. S. L. Vadehra (Kashmir).
Dr. K. Kadambi (Mysore).
Mr. N. Bhargava (Kotah).
Mr. S. A. Vahid (Hyderabad).
Mr. Parmal Singh (Gwalior).

WHEREAS

(*a*) In general, in the post-war period to date, all silvicultural research is still suffering from lack of adequate staff;

(*b*) In particular, one post of assistant to the key post of Central Silviculturist continues unfilled, to the serious detriment of progress in research and dissemination of accumulated scientific knowledge, although suitable and willing provincial officers exist.

SEVENTH SILVICULTURAL CONFERENCE, DEHRA DUN OCTOBER-NOVEMBER, 1946



Back Row (L—R) R.S. Gupta **(F.R.I.)**, S.A.A. Anvery **(I.F.R.C.)**, G. C. Dash **(Orissa)**, C. H. Holmes **(Ceylon)**, K. L. Lahiri **(F.R.I.)**, F. C. Osmaston **(D.F.E.)**, M.R. Rattan **(Punjab States)**, S. N. Kesarcodi **(Bombay)**, M. N. Bahuguna **(Rewa)**, Rao Bahadur M. S. Raghavan **(Madras)**, S. Singh **(Bikaner)**, R.M. Gorrie **(Punjab)**, F. G. Afridi **(N.W.F.P.)**, M. R. Khan **(Bhopal)**, H. C. P. Saksena **(Malwa States)**.

Middle Row B. P. Basu **(Bihar)**, S. Venkiteswaran **(Cochin)**, R. N. Datta **(C.P.)**, Jagdamba Prasad **(F.R.I.)**, C. Padmanab **(Bundelkhand)**, R. N. De **(Muyurbhunj)**, N. Bhargava **(Rajputana States)**, K. P. Singh **(Gwalior)**, B. C. Das **(Jodhpur)**, P. W. Davis **(Baluchistan)**, C. A. R. Bhadran **(I.F.C.)**, J. A. Wilson **(Madras)**, M. M. Srinivasan **(Assam)**, Ford-Robertson **(U. P.)**, K. Kadambi **(Mysore)**, Y. S. Ahmad **(Bengal)**.

Seated P. D. Raturi **(Tehri Garhwal)**, S. A. Vahid **(Hyderabad)**, M. D. Chaturvedi **(U. P.)**, K. I. Aggarwal **(Chamba)**, Rao Bahadur T. V. Venkateswara Iyer **(Travancore)**, J. C. M. Gardner **(F.R.I.)**, A.P.F. Hamilton **(I.G.F.)**, A. L. Griffith **(F.R.I.)**, E. W. Raynor **(U.P.)**, S. L. Vadehra **(Kashmir)**, H. F. Mooney **(Eastern States)**, J. Petty **(Bombay)**, E. A. Garland **(Sind)**.

THIS CONFERENCE RESOLVES THAT—

(1) *The attention of the Senior Officers' Conference be invited to the necessity for urgent action to fill the vacant Central post without further delay.*

WHEREAS

(*c*) Silvicultural conferences are now being held every 5 years and the Central Silviculturist's research programme is almost entirely based on the conference resolutions.

THIS CONFERENCE RESOLVES THAT—

(2) *The Central Silviculturist's research programme should be altered from a* 3 *to a* 5 *year period.*

WHEREAS

(*d*) Specialist training of silviculturists and silvicultural rangers at the F.R.I. has been found most desirable, and such training to be most effective, requires to be systematised.

(*e*) Continuity in silvicultural research is of primary importance.

THIS CONFERENCE RESOLVES THAT—

(3) *It is desirable that:*

(*i*) *Silviculturists and silvicultural rangers should only be selected after not less than* 3 *years experience as divisional (district) and range officers respectively and that for silviculturists at least* 2 *years additional previous experience as working plan officers is most desirable,*

(*ii*) *Silviculturists and silvicultural rangers should as soon as possible after appointment undergo at least* 6 *months specialist training at the F.R.I., which must include the first* 3 *months of the rains (June to August).*

(*iii*) *Silviculturists and silvicultural staff, if found suitable after probation, should remain in their posts for at least* 5 *years and every silviculturist should have a trained assistant who will be capable of replacing him.*

WHEREAS

(*f*) Compensation is necessary for the lack of amenities usually enjoyed by territorial officers, for the arduous and exacting nature of the work and above all for the special abilities and skill demanded.

THIS CONFERENCE REAFFIRMS resolution No. (3) under item 1 of the 1945 conference and RESOLVES THAT—

(4) *The attention of the Senior Officers' Conference be drawn to the desirability of securing adequate extra remuneration for all staff engaged in silvicultural research.*

WHEREAS

(*g*) Visits of provincial silviculturists to the F.R.I. and to other provinces interested in similar problems are still not as frequent as the interests of research demand, and Provinces and States would welcome more frequent visits by the Central Silviculturist, THIS CONFERENCE REAFFIRMS resolutions Nos. (3) and (7) of item 1 of the 1939 Conference, *viz.*,

"3". *"A Provincial Silviculturist should make it his business to visit other provinces where there is work of special importance to his own, to get first hand knowledge of what is being done. When a problem is common to a number of provinces, joint tours by those interested should, if possible, be organised to study it."*

"7". *"The conference emphasises the value of personal visits by the Central Silviculturist to their forests, to study their problems and to give advice, and it recommends that he should visit them more frequently than hitherto. It also recommends that Provincial Silviculturists should visit the Forest Research Institute more frequently to keep up to date in experimental technique and to discuss their problems."*

THIS CONFERENCE RESOLVES THAT—

(5) *The attention of the Senior Officers' Conference be drawn to the fact that the spirit of these resolutions continues to be of great importance.*

WHEREAS

(*h*) (*i*) The States Sub-committee has represented that the States appreciate fully the great necessity for silvicultural research. No organised silvicultural research has been undertaken except in Kashmir.

THIS CONFERENCE RESOLVES THAT—

(6) (*i*) *The attention of the Senior Officers' Conference should be drawn to the desirability of inviting the attention of all Darbars to the very great importance of this matter.*

(*ii*) *Appointing silviculturists without delay in each of the major States and elsewhere for*

groups of States in order to participate in the research work which is being carried on in neighbouring Provinces and States and at the centre, and to initiate research in States on up-to-date lines.

(*iii*) *Appointing State Silviculturists for the following individual States and groups of States:—*

(*i*) *Kashmir* (*already appointed*).
(*ii*) *Punjab States and Tehri Garhwal.*
(*iii*) *Gwalior and Rampur.*
(*iv*) *Central Indian States.*
(*v*) *Eastern States.*
(*vi*) *Rajputana States.*
(*vii*) *Western India and Gujrat States.*
(*viii*) *Deccan States.*
(*ix*) *Hyderabad* (*already appointed*).
(*x*) *Mysore.*
(*xi*) *Madras States.*

WHEREAS

(*j*) Co-ordination or avoidance of unnecessary duplication in research programmes is of great importance.

THIS CONFERENCE RESOLVES THAT—

(7) *Copies of all research programmes of Provinces and States should be sent to the Central Silviculturist and all those concerned with similar silvicultural problems.*

ITEM 2. ORGANISATION OF LEDGER FILING.

Committee.

Mr. Garland (Sind) (*Chairman*).
Dr. Gorrie (Punjab).
Mr. Ford Robertson (U.P.).

WHEREAS

(*a*) Full records in forestry are essential,
(*b*) A uniform system for recording information on forestry is required for its proper collection and dissemination,

THIS CONFERENCE RESOLVES THAT—

(1) *The Senior Officers' Conference be invited to stress the importance of providing adequate facilities for Silviculturists in Provinces and States and for the Central Silviculturist to collect and maintain records of all specific as well as general information.*

(2) *Provision of local information to Silviculturists by all executive officers is necessary so that his records can be complete.*

WHEREAS

(*c*) Howards' system for filing information on forestry was adopted for use in India, following the resolution on the subject by the 1929 Silvicultural Conference.

(*d*) This system has proved suitable in practice for the purpose for which it was designed.

(*e*) Instances have occurred in which unauthorised modifications of this system have been made in order to adopt it for purposes for which it was not designed in filing routine correspondence in forest offices.

(*f*) Unauthorised modifications of any filing system necessarily defeat the object of uniformity.

(*g*) Certain subjects, such as soil erosion are still not adequately sub-divided in the classification.

THIS CONFERENCE RESOLVES THAT—

(3) *The resolution of the* 1929 *Silvicultural Conference that Howards' system be generally adopted for use in India on filing information on forestry be reaffirmed.*

(4) *The attention of the Senior Officers' Conference be invited to the following clauses of that resolution which are essential for maintaining the integrity of the system.*

"(*i*) *Authority for the adoption of further sub-division should be vested in the Central Silviculturist. Whenever a provincial officer proposes to sub-divide any head, recommendations should be sent to the Central Silviculturist, and he should accept them as received or negotiate amendments if he thinks it desirable, particularly if other proposals have been received from another Province or State.*

(*ii*) *Alterations, if any, should be made by the Central Silviculturist with the agreement of the majority of Provincial and States Silviculturists.*"

(5) *The Central Silviculturist should call for suggestions from Provinces and States officers for suitable sub-division of subject heads at present not considered sufficiently covered, e.g., erosion.*

WHEREAS

(*g*) More information for specific ledger files tends to accumulate in the Provinces and States than at the Forest Research Institute.

(*h*) Much information in general ledger files at the F.R.I. is not normally communicated to the Provinces and States.

THIS CONFERENCE RESOLVES THAT—

(6) *Provincial and State Silviculturists be asked to supply copies to the Central Silviculturist when ledgering information for their specific files.*

(7) *The Central Silviculturist should send an officer to collect information already ledgered in Provincial and State files, general as well as specific, and Provinces and States should be asked to give all requisite assistance in this work.*

(8) *The Central Silviculturist, as an experiment should revive the monthly distribution of lists of ledger file titles of information put into his ledger files.*

(9) *Provincial and State Silviculturists, bringing with them suitable staff, should regularly visit Dehra Dun, preferably once each year, so that they can complete ledger files on which they require information from the records at the Forest Research Institute.*

ITEM 3. AFFORESTATION OF DRY AND DESERT AREAS.

Committee.—

Mr. Petty (Bombay) (*Chairman*).
Mr. Garland (Sind).
Mr. Davis (Baluchistan).
Mr. N. Bhargava (Kotah).
Bhai Charan Das (Jodhpur).

WHEREAS

(*a*) The Resolutions passed on Afforestation of Dry Areas at the 1945 Silvicultural Conference were generally approved by the Government of India and the Provincial Governments but the action taken has been, on the whole inadequate.

(*b*) It is now reliably estimated that the great Rajputana desert is expanding at the rate of about 300 sq. miles a year and many other areas of shifting sand exist in India.

THIS CONFERENCE RESOLVES THAT—

The resolutions of the 6th Silvicultural conference be reaffirmed and expanded as under :—

(1) *The attention of the Senior Officers' Conference be invited to the importance and urgency of the afforestation of these dry areas, particularly the fixation of shifting sands and the necessity for adequate action in the near future.*

(2) *Amongst the essentials that should have attention are :—*

(*i*) *Recruitment and training of the staff required to carry out operations. This staff will have to work in trying conditions and they must be well paid and properly housed.*

(*ii*) *Provision of the necessary funds. Requirements will be large and should form part of post-war reconstruction finance.*

(*iii*) *Propaganda on a large scale to endeavour to obtain the co-operation of the local population.*

(*iv*) *Legislation to give the necessary powers to enable work to be carried out.*

(3) *Research should be carried out in connection with :—*

(*i*) *Afforestation technique in the two rainfall belts 0 to 10 inches and 10 to 20 inches.*

(*ii*) *Contour trenching to ascertain the best methods.*

(*iii*) *Mechanical means of soil and subsoil working.*

(*iv*) *The relative merits and costs of live hedges and fencing particularly in connection with grazing areas.*

(v) *The propagation of suitable species and varieties of species including exotics. Particular attention to be given to methods of raising Anogeissus pendula.*

(vi) *The nutritional value of the pods of the various varieties of Prosopis juliflora and P. glandulosa.*

(4) *Experience gained should be carefully recorded and work at experimental stations both in Provinces and States should be closely co-ordinated preferably through the Central Silviculturist.*

WHEREAS

(c) In the dry areas there is generally an acute scarcity of grazing.

(d) If improvement of grazing is attempted in conjunction with afforestation operations opposition from the local people will be less.

(e) Attention to conservation and development of grass and forage as preliminary to production of wood is ecologically the correct approach.

THIS CONFERENCE RESOLVES THAT—

(5) *The attention of the Senior Officers' conference be invited to the importance of ensuring that wherever dry areas are to be afforested objects of management are clearly stated and measures for the improvement of grass and fodder production are considered.*

ITEM 4. THE CONTOUR PRINCIPLE IN COUNTER EROSION MEASURES.

Committee.—

Dr. R. M. Gorrie (Punjab) (*Chairman*).
Mr. Bhai Charan Das (Jodhpur).
Mr. S. N. Kesarcodi (Bombay).
Dr. R. S. Gupta (F.R.I.).
Mr. B. P. Basu (Bihar).

WHEREAS

(a) Denudation and erosion of both cultivated land and uncultivated waste are serious and increasing evils.

(b) The contour principle is the greatest single contribution so far known for improving the conservation of moisture and soil leading to increased productivity of all crops including grasslands and forests.

(c) Experimental work with machinery in certain Provinces and States has indicated that its use should be more fully tested and demonstrated under a wide variety of conditions for afforestation, agriculture, and improvement of grasslands.

(d) Permeability of the soil can be greatly increased by various means and this is likely to be of the utmost value in improving the prospects of afforestation and grass production on waste-land.

THIS CONFERENCE RESOLVES THAT—

(1) *The contour principle be adopted and demonstrated wherever the Forest Department is attempting to readjust land uses or to improve the productivity of waste and denuded land.*

(2) *Where labour is scarce or non-existant, or where a specific task is beyond human or animal labour the use of mechanical appliances is recommended for trial.*

(3) *The use of the sub-soiler should be investigated where it is likely to increase the productivity of land now under afforestation or pasture development.*

ITEM 5. FARM FORESTRY.

Committee.

Mr. F. C. Ford Robertson (U.P.) (*Chairman*).

Dr. A. L. Griffith (F.R.I.).

R. B., M. S. Rahgavan (Madras).

Dr. K. Kadambi (Mysore).

Dr. H. F. Mooney (Eastern States).

WHEREAS

(a) The vital role of forestry in Indian rural economy is now well recognised, both from protective and productive standpoints.

(b) Establishment of farm and village woodlots and other forms of farm forestry must be integrated with other aspects of rural rehabilitation in close collaboration with other departments concerned.

THIS CONFERENCE RESOLVES THAT—

(1) *The term " Farm Forestry " be accepted and broadly defined as the practice of forestry in all its aspects on farm and village lands, generally more or less integrated with other farm operations.*

(2) *The attention of the Senior Officers' Conference should be invited to the desirability of recommending in the strongest terms that Provinces and States :—*

(*i*) *incorporate farm forestry schemes in their rural rehabilitation plans ;*

(*ii*) *ensure that other departments concerned particularly with agriculture and animal husbandry co-operate closely at every stage.*

WHEREAS

(*c*) Under prevailing conditions of land pressure and rural custom, the replanning of the farm and village in general and the introduction of tree growth in particular may meet with serious rural opposition ;

THIS CONFERENCE RESOLVES THAT—

(3) *The attention of the Senior Officers' Conference be invited to the desirability of recommending strongly that Provinces and States :*

(*i*) *ensure by specific legislation the implementing of farm forestry programmes by individuals and communities through a suitable system of rewards and penalties ;*

(*ii*) *launch without delay vigorous programmes of publicity, education, practical training and research to further the cause of farm forestry. These should include tree-planting days or weeks, public and inter-departmental lectures, demonstration areas and tours.*

WHEREAS

(*d*) The demands of the larger centres of population cause villages within a wide radius to denude themselves of forest produce and manure, so jeopardising their present livelihood and plans for their future rehabilitation ;

THIS CONFERENCE RESOLVES THAT—

(4) *The attention of the Senior Officers' Conference be invited to the desirability of recommending strongly that Provinces and States establish plantations in addition to farm woodlots to the extent that they are necessary to meet the demands of the larger centres of population, utilising canal, roadside and railroad simultaneously with the farm forestry programmes.*

WHEREAS

(*e*) To bring forestry to the farm in a country where a vast majority of the population live on the land constitutes a formidable task :

THIS CONFERENCE RESOLVES THAT—

(5) *The attention of the Senior Forest Officers' Conference be invited to the desirability of recommending strongly that Provinces and States decide whether forest departments are to be expanded to organise and prosecute farm forestry or whether a central all-India agency comparable to the United States Soil Conservation Service should be created for the purpose.*

FINALLY THIS CONFERENCE RESOLVES THAT—

(6) *All such farm forestry schemes must be planned and their execution supervised by competent forest staff.*

ITEM 6. THE TECHNIQUE OF SOIL EROSION SURVEYS.

Committee

Dr. R. M. Gorrie, Punjab. (*Chairman*).
Mr. P. W. Davis, Baluchistan.
Mr. R. N. Datta, C.P.
Mr. S. N. Kesarcodi, Bombay.
Mr. F. G. Afridi, N.W.F.P.

WHEREAS

(*a*) An increasing volume of reliable evidence shows widespread and serious impoverishment of soil with an accompanying deterioration of the water regime.

THIS CONFERENCE RESOLVES THAT—

(1) *The facts required for a correct assessment of land use can be obtained by a simple reconnaissance and do not require an elaborate survey.*

WHEREAS

(*b*) The need for locating erosion damage is now obvious and

(*c*) A survey of the extent of existing erosion is an essential basis for land use classification, on which remedial measures must be based.

THIS CONFERENCE RESOLVES THAT—

(2) *A local, regional, or catchment plan is necessary, in order to prescribe remedial measures, such a plan requires more detailed information.*

WHEREAS

(*d*) The need is now felt for some form of code whereby erosion intensity may be accurately assessed.

THIS CONFERENCE RESOLVES THAT—

(3) *Steps should be taken to codify the procedure necessary in the collection and presentation of essential data in India, utilising such work as has already been done on the subject.*

WHEREAS

(*e*) Aerial reconnaissance has proved to be of special value in a preliminary appraisal of project areas

and

(*f*) More detailed aerial survey is of value in certain particular cases.

THIS CONFERENCE RESOLVES THAT—

(4) *The use of detailed aerial survey might with advantage be applied to difficult and remote country, unsurveyed tracts, and where sheet erosion cannot be located from maps or by ground survey.*

(5) *Aerial survey should be regarded as complementary to ground survey with which it must be correlated.*

WHEREAS

(*g*) Prescriptions for land use have to be carried out by more than one department.

THIS CONFERENCE RESOLVES THAT—

(6) *The attention of the Senior Officers' Conference be drawn to the desirability of making recommendations to all Governments to establish a Land Management Board with strong executive powers in order to co-ordinate the several branches of activity and to promote necessary legislation.*

ITEM 7. THE EFFICIENCY OF ENUMERATIONS.

Committee.—

Dr. A. L. Griffith (F.R.I.) (*Chairman*).
Mr. E. W. Raynor (U.P.)
Mr. R. N. Datta (C.P.)
Mr. S. L. Vadehra (Kashmir).

WHEREAS

(*a*) Enumerations are necessary for post war planning, particularly in private forests.

(*b*) In most provinces large scale enumerations are being carried out to assess the post-war growing stock and its normal yield capacity.

(*c*) The accuracy of enumerations is a matter of paramount and permanent importance.

(*d*) The work done by the Central Silviculturist during the past 18 months as published in *Indian Forest Leaflets* Nos. 83 to 91 and 93 shows that for the main forest types of India enumerations of 5 to 10 per cent. intensity give an estimate of the growing stock sufficiently accurate for normal working plan purposes, provided that the sampling is carried out with a full appreciation of the probable trends of the fertility gradients of the forest.

(*e*) During the past working season a number of large scale systematic partial enumerations have been successfully carried out, particularly in the U.P., the C.P. and Bombay.

THIS CONFERENCE RESOLVES THAT—

(1) *The attention of the Senior Officers' Conference be drawn to the importance of the results so far obtained and the successful practical use that has already been made of them.*

(2) *The attention of the Senior Officers' Conference be also drawn to the fact that little has yet been done to give effect to the Resolution of the 6th Silvicultural Conference that the staff used for enumerations should be of the highest quality and should receive extra remuneration.*

(3) *The Central Silviculturist should continue to keep closely in touch with eminent statisticians in order to obtain a mathematically satisfactory method of calculating the precision of the estimates of systematic sampling of systematically arranged data.*

(4) *The Central Silviculturist should issue at an early date a leaflet describing the essential preliminaries to the carrying out of partial enumerations. These should include delimitation of types and determination of fertility gradients.*

(5) *Further partial and full enumerations should be done in different forest types and different provinces, particularly in the high level deodar and fir and spruce forests of the Punjab, Kashmir and N.W.F.P. The provinces should supply the necessary data to the Central Silviculturist for analysis.*

ITEM 8. PASTURE AND FODDER.

Committee.—

Mr. J. A. Wilson, (Madras) (*Chairman*).

Mr. E. W. Raynor, (U.P.).

Mr. R. N. Datta, (C.P.).

Mr. Bhai Charan Das, (Jodhpur).

Mr. B. P. Basu, (Bihar).

Mr. S. L. Vadehra, (Kashmir).

WHEREAS

(*a*) It has been represented that in several Provinces and States there is no declared policy in respect of Pasture and Fodder.

THIS CONFERENCE RESOLVES THAT—

(1) *The attention of the Senior Officers' Conference be drawn to the importance of ensuring that policies on this subject are formulated.*

WHEREAS

(*b*) The policy of the past two decades has been to limit the powers of control over the grazing animal by forest officers and to reduce or abolish charges made for forest grazing.

(*c*) This policy has led to an excessive concentration of livestock of low quality on grazing grounds which has caused the progressive deterioration of the pastures and has resulted in soil erosion on a significant scale.

(*d*) Great improvement of deteriorated pastures is possible by the correct application of up to date technical knowledge and experience.

THIS CONFERENCE RESOLVES THAT—

(2) *The attention of the Senior Officers' Conference be drawn to the fact that extensive measures of pasture improvement are prevented by the failure to implement the resolutions of past conferences on the subject of control of the grazing animal.*

(3) *To prevent the further deterioration of pasture it is essential that the incidence of grazing be limited to the carrying capacity and that, after being grazed, pasture should be given rest to recuperate, e. g., some form of grazing regulation such as rotational or periodic losures.*

(4) *Limitation of grazing incidence must involve the exclusion of excess livestock. Utility cattle both draught and milch should be given preference of admission to pastures.*

(5) *Collateral research cn problems arising out of the items above should be undertaken.*

(6) *The attention of the Senior Officers' Conference be drawn to the fact that :—*

(*i*) *Effective limitation is most likely to be achieved by economic pressure aimed at the elimination of animals of least economic value. It is therefore desirable that grazing charges should be reintroduced where already abolished or be enhanced until the demand is reduced to balance production.*

(ii) *The increase of revenues accruing from (i) above justifies more expenditure on pasture improvement and provision of grazing facilities. It is therefore desirable that measures to this end should be taken and adequate staff provided for supervision.*

WHEREAS

(e) The fodder problem in many Provinces and States is urgent and cannot be solved immediately by direct methods alone, *i.e.*, by means of limitation of incidence and regulation of grazing

THIS CONFERENCE RESOLVES THAT—

(7) *Every effort should be made to supplement existing fodder and grazing resources by indirect methods such as introduction of grasses, legumes and fodder trees, and encouragement of haymaking and ensilage.*

WHEREAS

(f) In all future legislative enactments for the management of private estate forests and waste lands, provision for limitation of incidence and regulation of movement are essential in the interests of soil conservation, animal husbandry, and fodder and grazing resources.

THIS CONFERENCE RESOLVES THAT—

(8) *The attention of the Senior Officers' Conference be drawn to the necessity for such provision.*

WHEREAS

(g) Browsing particularly by goats has caused excessive and incalculable damage to forests and grazing grounds and has aggravated soil erosion.

THIS CONFERENCE RESOLVES THAT—

(9) *The attention of the Senior Officers' Conference be invited to the desirability of adopting strong measures with a view to the exclusion of goats and other browsers from forests and grazing grounds.*

ITEM 9. SEED COLLECTION, DISTRIBUTION, STORAGE, TESTING AND TRANSPORT.

Committee.

Mr. S. N. Kesarcodi (Bombay) (*Chairman.*)
Mr. Ford Robertson (U.P.).
R. B. Raghavan (Madras).
Dr. Kadambi (Mysore).

WHEREAS

(a) The subject of seed collection, distribution, storage, testing and transport is of vital importance in artificial regeneration work and has not yet received the attention that it deserves.

THIS CONFERENCE RESOLVES THAT—

1. *The resolutions passed at the sixth silvicultural conference under item* 3 *be reaffirmed and given effect to as early as possible, particularly as regards.—*

(i) *Attention to seed origins, in furtherance of which it is recommended that as soon as surveys of seed resources are over and seed plots established, full particulars should be furnished to the central silviculturist, who will continue to serve as the clearing house for information.*

(ii) *Employment of trained staff for seed collection work.*

(iii) *Training of forest subordinates in correct methods of seed collection, storage and treatment.*

(iv) *Establishment of seed testing stations.*

2. *The Central Silviculturist should issue early instructions on practical methods of disinfecting seed consignments.*

3. *Systematic research on all aspects of seed collection and use should be pursued by the Provinces and States and the Central Silviculturist individually and in collaboration.*

4. *The attention of the Senior Officers' Conference be invited to the desirability of:*

(i) *Forest departments undertaking the supply of forest seed to the general public.*

(ii) *Taking steps to secure from the railway authorities consession rates for transport of seed under certification by competent forest authority empowered in this behalf.*

WHEREAS

(*b*) Certain Provinces and States experience difficulty in obtaining adequate seed supplies of certain spp.

THIS CONFERENCE RESOLVES THAT—

5. *The attention of the Senior Officers' Conference be drawn to the desirability of provinces and States pooling their resources and where practicable building up reserves.*

WHEREAS

(*c*) In the case of bulk orders for foreign seed, suitable origins can best be ensured by pooling indents through the Central Silviculturist,

THIS CONFERENCE RESOLVES THAT—

6. *All bulk orders for foreign seed be placed through the Central Silviculturist.*

WHEREAS

(*d*) The Forest Entomologist should be notified of all outbreaks of seed infestation as soon as observed, whether before or after seed collection.

THIS CONFERENCE RESOLVES THAT—

7. *All Provinces and States should take action to furnish this information through their research agencies to the Forest Entomologist, noting whether such outbreaks are of frequent occurrence and economically important.*

ITEM 10. SOIL PROBLEMS.

WHEREAS

(*a*) Knowledge of Indian forest soils is still far from complete,

(*b*) It is necessary for forest research officers to know the details of methods of soil examination in the field,

(*c*) Large increases in irrigated plantations and the growing of trees on irrigation water are contemplated in post-war plans in a number of Provinces and States.

(*d*) The work on soils at the F.R.I. has been of increasing importance and has yielded valuable results.

THIS CONFERENCE RESOLVES THAT—

(1) *The attention of the Senior Officers' Conference be drawn to :—*

(*i*) *The inadequacy of the existing staff and the desirability of augmenting it by at least 1 assistant soil chemist, 2 laboratory assistants and 2 attendants.*

(*ii*) *The advisability of arranging a short course, for about 10 days, of elementary training in field examination of soils at the Forest Research Institute. It is suggested that, as well as research officers, those who will have to do the actual work in the field such as research rangers, foresters, etc., should also attend.*

(2) *Water problems of irrigated plantations and the minimum water requirements of species in irrigated plantations should be taken up as likely to be of considerable importance in connection with post-war plans.*

ITEM 11. RESTOCKING OVER-EXPLOITED AREAS.

Committee.—

Mr. R. N. Datta, (C.P.) (*Chairman*).
Mr. P. W. Davis, (Baluchistan).
Mr. S. N. Kesarcodi, (Bombay)
R. B. T. V. Venkateswara Iyer, (Travancore).
Mr. F. G. Afridi, (N.W.F.P.).

WHEREAS

(*a*) During the recent war the reserved forests have been over-exploited by concentrated as well as scattered fellings.

(*b*) Regeneration of areas worked by concentrated fellings, tending of forests already regenerated and tending of the regrowth resulting from scattered fellings have remained in arrears.

(*c*) The growing stock has been depleted of large timber and poles to a varying extent.

(*d*) Deterioration in the efficiency of fire protection has resulted in much damage to the forests and adequate remedial cultural operations have not always been carried out.

THIS CONFERENCE RESOLVES THAT—

(1) *The resolutions on item 2 of the 6th Silvicultural Conference regarding the necessary staff and organisation for revising working plans be re-affirmed.*

(2) *The attention of the Senior Officers' Conference be invited to the great disparity in the progress made in the Provinces and States as regards implementing the resolutions on item 2 of the 6th Silvicultural Conference and the Senior Officers' Conference be invited to stress the necessity for strong action where little or no action has yet been taken.*

(3) *All Provinces and States should examine the existing growing stock and formulate appropriate silvicultural measures necessary for the rehabilitation of the over-worked areas.*

WHEREAS

(e) Certain species which were of little economic value before the war have been found to be useful and new uses may be developed for many other species.

THIS CONFERENCE RESOLVES THAT—

(4) *The attention of the Senior Officers' Conference be invited to the desirability of consulting the industries concerned when deciding the species to be used in re-stocking the forests.*

WHEREAS

(f) As a result of over-exploitation, the protective value of the reserved and private forests has suffered in many areas.

(g) The private forests have been over-exploited extensively and to a considerably greater degree than the reserved forests and adequate steps have not been taken by the owners to ensure re-stocking.

THIS CONFERENCE RESOLVES THAT—

(5) *The attention of the Senior Officers' Conference be invited to the urgent necessity for advising all Provincial and States Governments to take immediate steps to restrict further exploitation and to adopt effective measures to re-stock the over-exploited areas in the reserved, private and communal forests.*

ITEM 12. THE EFFECT OF BURNING AND OTHER ACCESSORY OPERATIONS UPON THE SOIL AS AFFECTING ARTIFICIAL REGENERATION.

Committee.—

Mr. P. W. Davis, (Baluchistan) (*Chairman*).
Dr. R. S. Gupta, (F.R.I.).
Dr. R. M. Gorrie, (Punjab).

WHEREAS

(a) Experience shows that certain preliminary operations such as burning and soil working are usually followed by marked improvement in the growth of new crops.

(b) Present information is inadequate upon the specific factors which are operative under such treatments, and their interactions upon one another.

(c) Such information is likely to be of special value in areas where artificial regeneration is difficult, for example in dry districts, or where material for burning is scanty, or where the lack of humus hampers agricultural and silvicultural operations.

THIS CONFERENCE RESOLVES THAT—

(1) *Further research be conducted upon different classes of soils to asses the significance of the factors affecting plant growth and to amplify existing knowledge on the subject particularly in the study of soil bionomics.*

WHEREAS

(d) The above problems cannot be fully investigated without the services of a Soil Bacteriologist.

(e) A soil Bacteriologist is also called for to investigate problems in Farm Forestry particularly in dry areas.

(f) No provision has hitherto been made for the appointment of a qualified officer at the Research Institute or in the Provinces and States.

THIS CONFERENCE RESOLVES THAT—

(2) *The appointment of a Soil Bacteriologist at the Forest Research Institute be recommended for the consideration of the Senior Officer's Conference.*

WHEREAS

(g) Burning has certain recognised adverse effects on soil, *e.g.*, destruction of organic matter, increased susceptibility of the areas to erosion after burning and reduced priority in clayey soils.

(h) There is need to enquire into the possibility of conducting other operations, such as soil working, green manuring and the use of grass leys or leguminous cover crops as an alternative to burning in afforestation measures.

THIS CONFERENCE RESOLVES THAT—

(3) *Experiments be carried out to evolve a suitable technique whereby burning could be replaced by other operations which would help to conserve humus in the soil and maintain desirable physical properties.*

ITEM 13. IRRIGATED PLANTATIONS.

Committee.—

Mr. J. Petty (Bombay) (*Chairman*).
Mr. S. A. Vahid, (Hyderabad).
Dr. R. M. Gorrie, (Punjab).
Mr. N. G. Pring (N.W.F.P.).

WHEREAS

(*a*) Areas provided with irrigation are normally densely populated.

(*b*) Wood for fuel and timber for housing and agricultural implements must be provided in such areas.

(*c*) Irrigated plantations of suitable tree crops are the most economic source of supply of these requirements.

(*d*) Such plantation crops being perennial instead of seasonal can take a large part of their water requirements at such times and in such quantities that withdrawn from the irrigation systems can alternate, instead of being competitive, with agricultural demands.

(*e*) Large areas of plantations assist in preventing excessive accumulations of sub-soil water and afforestation can be a means of reclaiming areas already water logged.

THIS CONFERENCE RESOLVES THAT—

(1) *The attention of the Senior Officers, Conference be invited to the importance of, and the necessity for advance planning in respect of plantations, shelter belts and all aspects of farm forestry whenever irrigation projects are being examined.*

(2) *Clause* (*b*) *of the Resolutions on Item* 6 *of the* 6*th Silvicultural Conference be reaffirmed that:*

"*Research be carried out in connection with irrigated plantation technique.*"

(3) *In all irrigated plantation reports and records, the standard terms used by irrigation engineers such as cusec, delta, duty, etc., should always be employed.*

ITEM 14. CASUARINA EQUISETIFOLIA PLANTATION TECHNIQUE.

Committee.—

R. B. Raghavan (Madras) (*Chairman*).
Mr. S. N. Kesarcodi (Bombay).
Mr. S. C. Dash (Orissa).
Mr. C. H. Holmes (Ceylon).

WHEREAS

(*a*) The insufficiency of fuel for the normal needs of the population has been felt severely in many parts of India.

(*b*) *Casuarina equisetifolia* is capable of rapid growth under suitable conditions, and provides good fuel and charcoal,

(*c*) the wide range of views held on several vital aspects of its silviculture indicate the necessity for determining the best and most economical methods of raising the species.

(*d*) Research is essential for the expeditious determination of such methods.

THIS CONFERENCE RESOLVES THAT—

1. *It be recommended that while present plantation programmes continue, research on Casuarina plantation technique and further study of its silvicultural requirements should be undertaken as early as possible.*

WHEREAS

(*e*) Bombay, Orissa, Madras, Mysore and Ceylon, already have Casuarina plantations and

(*f*) other Provinces and States are interested in this species.

THIS CONFERENCE RESOLVES THAT—

2. *Co-operative research by all interested Provinces and States should be initiated.*

ITEM 15. THINNING RESEARCH.

Committee.—

Mr. E. W. Raynor (U.P.) (*Chairman*).
Dr. R. M. Gorrie (Punjab).
Mr. R. N. Datta (Bihar).
R. B. M. S. Raghavan (Madras).
Mr. Jagdamba Prasad (F.R.I.).
Mr. S. N. Kesarcodi (Bombay).
Dr. A. L. Griffith (F.R.I.).

WHEREAS

(*a*) Very little work on the resolutions of the 1939 conference on the subject of thinning research has been possible owing to the war,

THIS CONFERENCE RESOLVES THAT—

1. *The resolution of the* 1939 *Conference* (*with the exception of No.* 3) *be reaffirmed.*

WHEREAS

(*b*) There is great need of guiding the conduct of research in India on thinning forest tree crops, in the interest mainly of uniformity, and

(*c*) There is a vast field of possible problems to explore on this subject in order to ensure the taking up immediately of those with the highest priority,

THIS CONFERENCE RESOLVES THAT—

2. *The object of thinning research in India should be defined as the determination of the optimum thinning regime* (*including intensity and interval*) *for each forest crop in order to produce the maximum financial return of which the locality is capable without impoverishment, consistent with the silvicultural requirements of the species.*

3. *The existing canopy classes be enlarged by two. They should be termed No.* 7 *Reproduction and No.* 8 *Overmature.*

4. *Every new set of thinning research plots should have a control* (*unthinned set*) *for comparison with the treatments.*

5. *Means should be devised for the direct actual assessment of the comparative rate of growth in relation to the final crop trees as determined by a continuous study of selected trees. A combination of observational and statistical methods will probably be necessary.*

6. *Thinning research should for the present be directed to:*

(i) *Teak, Shorea robusta and mixed coppice crops.*

(ii) *Irregular crops and unevenaged natural regeneration and mixed natural or plantation crops.*

(iii) *The effect of advance thinnings for the main light demanders should be compared with the ordinary grades of thinning. The application of results will depend on the type of produce required.*

(iv) *The determination of the rate of heartwood formation of teak, Shorea robusta and other important species.*

(v) *The effect of pruning and debudding, the latter especially for conifers,*

7. *Early steps should be taken by the Central Silviculturist to publish the compilation of the latest methods of thinning research in the revised silviculture research code.*

8. *The tending of irregular crops by the method of single stem silviculture as described in the C. P. paper should be further investigated as it has very wide application in other Provinces and States and to other forest types.*

9. *The technique proposed in S. Partap Singh's paper should be further examined with the collaboration of the author.*

RESOLUTION ON ITEM 16. PUBLICATIONS

Committee.—

Dr. A. L. Griffith (F.R.I.) (*Chairman*).
Dr. R. M. Gorrie (Punjab).
Dr. H. F. Mooney (Eastern States).

WHEREAS

(*a*) Technical publications are permanent records,

(*b*) The war and war emergency period are now over,

(*c*) Owing to the poor quality of material used, some publications of permanent value issued during the war are already seriously deteriorating.

THIS CONFERENCE RESOLVES THAT—

1. *As soon as possible pre-war standards of printing, paper, illustrations, and binding should be restored.*

WHEREAS

(*d*) A number of the larger silvicultural publications need revising and reprinting and this has not been possible owing to war conditions.

(*e*) The need for these publications is now still more urgent owing to the rapid expansion of the forest colleges.

(*f*) It is likely that the central silviculturist will shortly have his normal staff again.

THIS CONFERENCE RESOLVES THAT—

2. *Priority should be given to the revising and reprinting of the Silviculture Research Code Vol. I. The experimental manual and Vol. III. The yield, volume and stand table manual.*

3. *The Central Silviculturist be authorised to initiate the revising and reprinting of Troup's "Silviculture of Indian trees". This production should be printed species by species as it is completed in a special set of Indian Forest Records so that they can be bound into convenient volumes. It is suggested that suitable officers in the various Provinces and States should be invited by the central silviculturist to collaborate in respect of their own local species.*

4. *The revision of I.F.R. Silviculture (n. s.) I (1). Champion's "Preliminary Survey of the Forest Types of India and Burma", although very desirable and necessary is not as urgent as the publications noted in 2 and 3 above.*

WHEREAS

(*g*) Present arrangements for the publicising and sale of Provincial and State publications is unsatisfactory.

THIS CONFERENCE RESOLVES THAT—

5. *Provinces and States should notify the central silviculturist of impending publications well in advance of issue so that he can inform other Provinces and States likely to be interested to ensure that a sufficient number of copies are printed.*

6. *The attention of the Senior Officers' Conference should be drawn to the desirability of:*

(i) *A sufficient number of copies of publications of scientific and publicity value being set aside for distribution as free complimentary copies.*

(ii) *Establishing a sales organisation within the F.R.I. for Provinces and States publications for the benefit of students and others.*

(iii) *Recommending that complimentary copies of all Provincial and States publications should invariably be sent to (a) the Central Silviculturist for record purposes and (b) to the Editor of the Indian Forester for review in that journal.*

THIS CONFERENCE RESOLVES THAT—

The attention of the Senior Officers' Conference be invited to the proposal to inaugurate a States Forest Conference and to the resolutions passed at a meeting held by delegates from States attending this Conference.

PROPOSAL TO INAUGURATE STATE FOREST CONFERENCES.

States Sub-committee.—

Dr. H. F. Mooney, Eastern States (*Chairman*).
Mr. S. A. Vahid, Hyderabad.
Mr. Bhai Charan Das, Jodhpur.
Kr. Parmal Singh, Gwalior.
S. Shamser Singh, Bikaner.
Mr. H. P. Saxena, Dhar.
Mr. S. L. Vadhera, Kashmir.
Mr. P. D. Raturi, Tehri Garhwal.
R. B. T. V. Venkateswara Iyer, Travancore.
Mr. M. N. Bahuguna, Rewa.
Dr. K. Kadambi, Mysore.
Mr. Mehta Ram Rattan, Patiala.
Mr. Nandan Bhargava, Kotah.
Mr. C. Padmanab, Eastern Bundelkhand Agency.

WHEREAS

Many of the problems facing States are not always identical with those of the provinces, and in view of the great variations in the standards of silviculture and forest management existing between individual states as well as between the States and Provinces in general.

THE STATES DELEGATES ATTENDING THIS CONFERENCE RESOLVE THAT—

(1) (i) *Periodical State silvicultural conferences should be inaugurated at which silvicultural problems affecting States could be discussed.*

(ii) *These conferences should normally be held every fifth year or more frequently if necessary and should be synchronized to take place about twelve months prior to the All-India Silvicultural Conference so that subjects for discussion at the latter could be proposed.*

(iii) *The first conference might be held some time during the cold weather of 1947-48, the actual venue to be decided later.*

(iv) *The number of delegates be limited to thirty.*

(v) *If this proposal is approved by the Chamber of Princes, Dr. Mooney, Chief Forest Adviser, Eastern States be asked to act as Convenor and Secretary of the first conference.*

(2) *Seats at the next All-India Silvicultural Conference be allotted as follows :—*

Kashmir	2
Punjab States including Tehri Garhwal	2
Central India States with Gwalior and Rampur	3
Rajputana States	2
Western India and Gujrat States	1
Deccan States	1
Hyderabad	2
Eastern States	2
Mysore	1
Madras States	2
	18

and that the Inspector General of Forests be requested to allot two more seats to States for special allocation.

(3) *This resolution be submitted to the Chamber of Princes through the Inspector General of Forests for their consideration.*

DATE AND COMPOSITION OF NEXT CONFERENCE.

WHEREAS

(a) Experience has shown that in the interests of efficiency and the saving of unnecessary correspondence the method of convening silvicultural conferences needs to be systematized.

THIS CONFERENCE RESOLVES THAT—

1. *The eighth silvicultural conference be held at the Forest Research Institute, Dehra Dun in October/November,* 1951.

2. *The number of delegates should be limited to about* 50 *and these should normally be* 2 *per Province and* 1 *per State or group of States and interested neighbouring countries such as Burma and Ceylon.*

3. *The I.G.F., the President, F. R.I. and a States Committee should be empowered to invite extra delegates if necessary who are experts in particular subjects.*

4. *The Central Silviculturist should be Secretary of the next conference and should perform the functions of Conference Secretary when convening the conference.*

5. *The Senior Officers' conference be asked to approach the Government of India, the Provincial Governments and States Durbars, etc., in order that the conference Secretary be permitted to correspond direct with the heads of departments in the Provinces or States concerned and with the delegates.*

QUOTH THE PANDIT.

By F. R.

"The trouble about this erosion business," remarked the Pandit, wagging a long finger at me, "is its muddled and inchoate terminology".

"Surely", I said, "the text-books— ".

"The first comprehensive text-book on the subject has yet to be written", pursued the Pandit calmly. "And when it is, mark this, it won't be entitled Erosion at all—not if it knows its business".

"Perhaps, Sir, you would explain?"

The Pandit nearly permitted himself a snort. "Look here, young feller. Imagine you're a Panjabi, and one not so fine day in August your most fertile field gets buried under a hundred tons of sand and gravel from one of those—what do you call them?—*chos*. Maybe your good soil is more or less intact, underneath, but you can't get at it; it's no earthly—yes, no *earthly*-good to you. Lost, in fact".

"Um", I said doubtfully.

"Or let us imagine you're a Bihari, down Patna way, and a monsoon flood comes along, inundating your land. Then when it recedes, you discover that a portion of your fields has got permanently waterlogged and useless, whereas a neighbour finds himself with a bit of entirely new land formed from deposited silt. Well, now, suppose I came along in cases such as these and commiserated with you on your serious "erosion", what would you think?"

"M-m—I'd probably think you were bats" I said politely.

"Bats?—er, yes, to be sure. Misapprised is perhaps a more appropriate term. You would feel, in short, that I had, to borrow your slang, got the wrong end of the stick? Quite so. This word EROSION comes from the Latin, meaning to gnaw away; in its proper place an excellent and exact term. Whereas, in the cases I have just postulated, we would be witnessing one of its *effects*, namely the piling up or aggradation of -er, detritus, in the last place one would welcome it".

"Excepting", I ventured cautiously, "in your case of the silt?" I could have a shot at being precise too.

"Aha—yes, young man. An excellent, a capital point. I shall return to it. But it must not divert us from my thesis, which is simply this. That we, namely scientists and people in general, have been taking as the title of our so important study, only one phase or aspect of it. Making, in brief, the word erosion cover all its varied and multitudinous effects and consequences. It is rather as if one were to write a book on explosives and call it detonators or primers; or, shall we better say, one on traumatic sepsis and call it wounding. Now, erosion in all its forms may very properly be looked upon as a wound, a wound on the living skin of the Earth; one that, in the nature of things, is infected *ab initio* and therefore liable to spread from its focus. But to comprehend all its varied, far reaching and perdurable consequences in the one word "erosion" is as misleading and unscientific as for a doctor to refer to "wounding" when he meant "septicaemia". And erosion experts, young fellow, if they know their job, are land doctors and should acquire some of the precision belonging to the medicine of the human body".

"I begin to see what you're driving at, Sir" I felt moved to say, "A mouse leaving its—er, cards on the supper table may have eroded the cheese but—"

"Quite, quite. You have grasped the point. But you will please spare me any levity", he raised a slim hand, "the subject is far too serious. As I have hinted, our terminology relating to erosive phenomena remains rather in the nursery. We need, I consider, to continue where the geologist left off

years ago. His interest in it was and remains essentially impersonal—centered in the long-range degradation of land masses and their rebuilding again in the sea. We budding land doctors, on the other hand, are concerned with the human, social-economic aspect, with the use and abuse of all that man has to live on—and *off* —that is, the outermost living crust of Mother Earth. And we haven't yet properly sorted out our ideas".

He grabbed a sheet of paper, poising his pencil. "Look here. It's really quite simple. When one talks loosely of erosion, what does one mean? Essentially, surely, the forcible, untimely transfer of a portion of the earth's surface to some other place on it by the elemental forces—chiefly by water or wind. By water, downhill; by wind, not necessarily so. But in both cases, never a transfer *in toto*, like one transplants a tree with its lump of earth, but a disintegration and a scattering on the way. Mark that; an uprooting and a spewing. So we have three phases—loss, transfer and gain, or, let us say, erosion *proper*, translocation and deposition. Very good. I now propose to take these phenomena in turn and sort out the nomenclature properly belonging to each". He began jotting, his pencil busy across the sheet. "For a comprehensive term embracing all aspects of the subject, I suggest LANDEGRADE". He pronounced it crisply, as if it were one word and wrote it down so, in block capitals; not even a hyphen. "Right, that releases poor, overworked "erosion" from its false and pretentious position. It has been gnawing at *my* sense of fitness and precision long enough. Now let us set down all the well-known terms associated with it, in a decent and well ordered hierarchy". He had warmed to his task, as eager now as a schoolboy, and I bent over to watch his rapid but clear calligraphy filling the page with names and brackets and numbered notes. His running commentary was made with hardly a glance in my direction. "Denudation—that's 'to make naked'—comes early. By the way, my boy, a curious point there, for the lexicographer. No less an authority than the *Shorter Oxford Dictionary* defines denudation in its geological sense, as 'the disappearance of forests or surface soil especially by natural agencies'. Note, if you please, the 'especially'". His pencil paused. "Any comment?"

"Only that the emphasis seems wrong, Sir. No one has ever seen a forest disappear *naturally*. He'd have to live millions of years, I suppose".

"Quite so", replied the Pandit. "It would be more practical and to the point to write 'especially by the malpractices of man', both for forests and for soil. The dictionary qualification bears quite a false emphasis. It is, from the human standpoint, academic and myopic—in fact, thoroughly Victorian. It 'dates' as they say, dates badly. However, let us pass on. Having put Erosion in its proper place ... *so* ... I require to distinguish between *site* or *focal* erosion and *transit* erosion; the important working difference between, say, a gully and the sweeping away of fields by floodwater. Useful that. In the transit phase, too, I recognise a sub-distinction—you should not think me pedantic; a distinction, I repeat, between *riparian erosion*, as in the eating away of the banks of a water-course, and *irruption*, which denotes the extreme phase when the waters have grown so big and burdened that they breach their confining banks and cut through the countryside, may be to form a permanent new bed. Like the Kosi in Bihar. A river with a settled course is said by geologists to have a stable regime; it may overflow at times but it will not irrupt, chiefly because it is blessed with a properly protected catchment-basin. The Ganges and many other Indian rivers, alas, are not. The hillman with his axe and his beast and his torch has turned the catchment basin into a dreadfully efficient water *shed*. I am sorry, by the way, that these two terms are still used synonymously—we land doctors or conservationists spend our lives trying to increase the "catch" and decrease the "shed"..But I shall not labour the point. You should merely remember that rivers are either stable or, when they irrupt, *vagabond* and river vagabondage is a danger signal, showing that the river has run amok, goaded by reckless, ignorant man, who looks upon its vagaries as an Act of God. Huh—*pace* the Oxford Dictionary's ideas on denudation, I should say an Act of Clods. What else, pray, can you call people who treat so wantonly their basic wealth, the precious topsoil? But I digress somewhat. During transit, as I have remarked, rivers drop their load, now here, now there, according to their varying velocity and specific burden. Here, then, you have the phase of deposition, the final act in the tragedy of

erosion—or, as you should learn to say, of landegrade. Now, just what gets deposited? Soil? Not always, by any means. It may be anything from the finest mud to rocks the size of this house, for such is the terrifying power of wanton water."

"You used the term detritus, sometime back" I ventured. "What's wrong with that, Sir? If I remember my Latin, it means anything that is rubbed away".

"Good, my boy". For the first time the Pandit almost beamed on me. "You do remember your Latin. And your geology. But I fear I am going to disappoint you. I entertained the suggestion myself but have rejected it. On two grounds, one slight, I admit, the other substantial. As regards the former it is not always strictly true that the river's burden, or the wind's for that matter, has been worn away from its place of origin or even worn in transit. For example, the bodily dislodgement involved in a landslip or an undermined bank. A trifle captious, perhaps. But the really serious objection consists in this. I may continue to employ the concrete noun, detritus, which has the sanction of long scientific usage but what I am seeking is a word to cover the act of its deposition. We possess established terms in respect of certain of its components—silting or siltation, for example; and we could admit "sanding" (as we do for floors), even "gravelling" and possibly "bouldering" if needed; while "sedimentation" and "alluviation" are already accepted for the finer constituents of deposition. But from "detritusation" or "detritusing" I frankly recoil. Yet a term we must have; the subject demands it. Well, I have pondered this for long and have found a solution, a good solution. It lies in the blessed, the felicitous word "*debris*" which we have long naturalised from the French. Curious, is it not, that we, a more wasteful people than the French and therefore the creators of far more rubbish, should have to borrow such a word from them? Perhaps our wasteful ways give us the habit of borrowing... Be that as it may, I have seized on this word and offer to you its derivative, as a suitable and much needed new term in our Landegrade vocabulary". And he wrote it down with a sort of triumphant flourish in large block letters while I leant forward and read—

DEBRISATION.

The Pandit gave his pencil a hasty sharpen, glancing at me keenly the while. "Well, young fellow? You don't like the look or the sound of it? Huh, that will pass in a day's use. It is the same with any new word. Why, it's so useful a term, fills such a gap on our nomenclature that I am persuaded you will see it in the very first text book written on landegrade. Useful and peculiarly appropriate. You lift your eyebrows? Let me remind you that "debris" has geological sanction for everything covered by the term detritus—silt, gravel, stones and the rest. Let me further draw your attention to what actually gets carried and therefore ultimately deposited by a flooded river. Is it all detritus? Does one not, alas, see shrubs and trees—raped vegetation of every sort—in fact, the whole lamentable products of ravished and denuded Nature? I forbear to speak of animal or human life or the artifacts of man—his riven bridges, even the contents of his home..... And you must further be aware, as a practical forest officer, that waterborne trees can greatly aggravate the transit erosion phase, by causing jams on bridges, for example, and the bursting of dams and embankments. On all counts, therefore, I hold that debris is a better term than detritus and "debrisation" a peculiarly apt term for the whole phase of deposition. In its eleven letters we can comprehend everything from the local silting of soil pores on a bare Himalayan hillside — that insidious, unnoticed initial stage of a tragic sequence—to the burial of a field in the distant plains under a mass of boulders and jungle jetsam. You may look upon it as the solid component of inundation—and its horrid hallmark".

I watched him in silence as he added a few notes and underlinings to the sheet before him. Then, apparently satisfied with his handiwork, he pushed the paper across to me.

"There's a fairly complete picture of Landegrade for you, young man, so far, at least, as its more direct effects are concerned, and with the new terms and the old each in their proper place. I have omitted the agencies of frost and sun and glaciation as of only secondary concern in what constitutes a pressing social and economic problem the world over. Read it through and see if it does not accord with the facts and processes you know but have lacked adequate words to describe and classify".

And this is what he had sketched out—

LANDEGRADE.

Chief cause: improper treatment of soil and its vegetative cover and creator, (deforestation, devegetation).

Chain of effects: soil deterioration, *viz.*, leaching of plant nutrients—loss of fertility, infiltration capacity and coherence, loss of productivity and then disintegration.—

(1) SITEROSION and denudation.

Note: Siterosion includes everything from soil-blowing, sheet erosion and finger gullies to deep ravines. Landslip scars are just a special dramatic phase, precipitated by a critical angle of repose—gravity acting directly; normally it works through water.

LAND RECLAMATION

Chief objective: the control and conservation of rain-water, achieved by—

(*a*) *contouration, viz.* terracing and contour ridging.

(*b*) *conservation tillage: e. g.* contour ploughing, clodding, stubble-mulching.

(*c*) *conservation cropping: e. g.* strip and cover crops; planned rotations.

(*d*) *soil fixation:* (*i*) mechanical, *e.g.* brush wattles; (*ii*) vegetational, *e. g.* by grasses, legumes, shrubs or trees.

(*e*) *bunding; viz.* check dams of every sort, debris basins.

and also of wind, achieved by—

(*f*) *shelter belts.*

The moment debris moves, i.e. is carried away by water or wind, some degree of—

(2) TRANSIT EROSION begins.

		Countermeasures—
(a) by water: (*water-borne debris*)	(*i*) *riparian erosion* or bank-cutting is its commonest form.	floodwater control, by *e.g.* dikes, revetments and retards.
	(*ii*) *irruption* or bank bursting (breaching) is an acute form.	
	(*iii*) *debris flow* is a special combine of (*i*) and (*ii*), issuing from steep storm-watersheds.	
(b) by wind (*wind-borne debris*)	(*iv*) *scarifying* and *desiccation* of vegetation and, more severe,	
	(*v*) *scouring* of the land surface—include wind scoops and 'bunkering'. Geologically known as 'deflation'.	

Note: The transit erosion phase is essentially dramatic, including high floods, debris and mud-flows, for water; and dust-storms for wind. The shifting dune is the surface counterpart of the dust-storm but has burial rather than erosive characteristics, hence more properly considered as a form of debrisation. (See below).

Sooner or later, the transit phase ceases and the various components of the transported debris get deposited giving rise to—

(3) DEBRISATION.

Debris=(*i*) eroded vegetation (trees the most important)

(*ii*) detritus proper silt (mud........siltation or silting) } sedimentation or overwash (Am.)

(sand........sanding).

(gravel....gravelling).

(pebbles and shingle).

(stones and boulders....boulder-burial).

(rock masses........rock piling).

Note: Distinguish (a) *precipitant* water, *i.e.* the water falling on an area direct from the clouds, and

(b) *affluent* water, *i.e.* surface water coming to an area from outside.

Also "erosive" from "erodible". The former means the *capacity to erode* (something)—cf. abrasive; the latter means the *susceptibility to erosion.* Thus a detritus-charged torrent is highly erosive; while chalk is highly erodible. The terms are NOT interchangeable.

* * * * * * * * *

It was the Pandit who first broke the silence. "Well, young man, what have you to say? I expect, I might tell you, brickbats not bouquets. That is ever the lot of the reformer".

I took a deep breath. "Just one or two points, Sir", I ventured.

"Pray proceed".

"You have left out the commonest term of all, one that we land doctors are always using—soil conservation".

The Pandit's eyes twinkled behind their glasses. "That, I confess, was deliberate. Put it in by all means but, if you please, *below*, not in place of Land Reclamation which is a more comprehensive term and the proper antonym of Landegrade. Just as soil loss is a cardinal feature of landegrade, so soil conservation is a cardinal feature of land reclamation; but it by no means constitutes the whole process. Stabilising sand dunes in Michigan or in the Landes of France is hardly an act of soil conservation although it leads to that as soon as soil can be formed. Nor is stabilising a road-fill or a landslip. To conserve means to keep from decay, change or destruction—which is what a conservator does for his forests, I believe?—and you cannot conserve what isn't there. But all these activities are most definitely reclamation or regeneration. Nevertheless" and he sighed, "Use is a tyrant, as the practical Romans used to say, and the term conservation will no doubt continue to be employed to cover every aspect of reclamation work. Hm—anything else?"

"Well, yes. What about this silt business?"

"Kindly be more explicit".

"Sometime back you agreed, Sir, so far as silting is concerned, that—er—debrisation was beneficial".

"I did not".

"Well,—"

"I said you had made a capital point—a very different thing".

"Would *you* elucidate, please?" Panditji seemed to be hedging and I wasn't going to let him off.

"Gladly. Listen. If I tore your one and only coat off your back, put it through a wet mangle and distributed bits of it to a lot of beggars, would you call that a good thing?"

"Hardly, Sir, but—"

"Neither should I. Even the beggars would not benefit much. And it is precisely that way with silt. Mark and digest this. Both water and wind, the prime eroders and transporters of soil, work havoc with it, for they disintegrate it in the process. Soil transported is soil aborted. It has lost structure, tilth. The Egyptian *fellahin* and the Bengal *ryot*, blessing the fruitful river that casually tosses them, one season silt, another, maybe, sand or stones, are beggar beneficiaries, receivers of damaged goods. And worse—*stolen* goods, for their precious silt is so much *raped soil*. Never forget that. Their miserable downstream gain is the hillman's irreparable loss; and the fact that the hillman has only himself to blame does not justify the wretched transaction. No, wanton water pays poor dividends, young man, and it would not be far fetched to rhyme silt with guilt. You smile? I assure you I am in deadly earnest. Any other questions?"

"Yes, if you please", I said. "What's all this about precipitant and affluent water? Is the distinction necessary?"

The Pandit nodded vigorously. "I have definitely found it so" he replied, "if only to clear certain misconceptions about the precise role water plays in the erosion process. Let me take a local illustration of what I mean—your Doab ravines in the U.P. It has been said and even written that they are eating into the tableland by *inducing sheet-erosion*".

"The local people, Sir, say they are caused by white ants—or else by the will of God".

"Pray attend to my point. The notion is erroneous, topsy-turvy; it is the sheet-erosion that induces the ravines. These have no suctorial power by which they grow. If you were able to skirt the whole ravine area with an effective *bund*, so that only precipitant water could fall on it—mark that—ravine growth would for all practical purposes be halted. And why? Simply because of the lack of *affluent water*. You perceive now why I am at pains to distinguish between the two? It is affluent water—the run-off from above—that is the villain of the piece, the great eroder. Ah! you have something to say?"

"Yes, indeed, Panditji. It's this. Even with your imaginary protective *bund*—

"Hypothetical, Sir".

"—your hypothetical *bund*—whenever rain falls on the bare ravine area, it necessarily becomes affluent at once and so must start to erode. It seems to me a distinction without a difference—or without any useful difference".

"Good for you, my boy. But not good enough nevertheless. Let me grant your thesis, that every raindrop will start rolling downhill, each one a potential eroder. All right—erosion there will be, I concede it. But consider for a moment the gully heads that are eating back into the tableland. We have prevented, you remember, any water tumbling into them from outside by our marginal *bund.* Do you suppose that the minor amount of water falling on them from the clouds, direct on the gully heads, is going to cause appreciable erosion? Further down, as it gains in volume, velocity and detritus, yes; right at the bottom where the gullies coalesce, definitely so. But *not at the head.* Get that into yours, if you please. Precipitant water under these conditions would gradually wear down the whole ravined area, and in the fullness of time leave nothing but one huge flat-bottomed bay at about Jumna level, surrounded by steep cliffs, these cliffs being nothing but the coalesced heads of your present gullies. No, these latter can grow only by affluent water and your Doab cultivator, by his bad husbandry, both of field and flock, of crops and cattle, provides all the run-off required for his own ruin. Or for 'run-off' should I say, 'run-*in*'? But you have grasped my point?"

I assented.

"Well, then, you can grasp one more, one that is absolutely fundamental. Listen". For a Pandit he suddenly became quite excited and leant forward, thumping the table. "All conservation work, all land reclamation, I should say, is based on just a few elementary facts of hydraulics, allied to one cardinal principle. Thus —it rains; water flows. It must either sink into the ground or flow over it. Water on the move is dangerous because of its tremendous power to reive and rape; when water move-soil moves, be it ever so little. Hence one fundamental principle of soil husbandry —HALT THE RAINDROP WHERE IT FALLS. Put that on a card and stick it in every schoolroom in the country—and in every council chamber too. All conservation practices—all contouration and bunding, all conservation cropping and tillage —have this as their basic idea—to impound the falling rain, as one would impound vagrant cattle. To the extent that you fail, you will get *soiled* water; for affluent water, like affluent man, always becomes more or less soiled, soiled by acquisition. Even should there be more water than you want, first of all impound it, then lead off the surplus under control. Water evenmore than fire, is a fine, no, an indispensable servant to man but a most terrible master; for it can consummate the rape of the Earth, which is all, in the last analysis, that we have to live by. It is doing so now, all over the world". He paused for breath, sitting back in his chair. I seized my opportunity.

"But, Panditji, surely one cannot *stop* erosion? It has been going on for millions of years before Man came on the scene. Any sedimentary rock proves that. Don't geologists say that the Deccan plateau is the worn base of a once mighty mountain system?"

"What of it, young man?" he countered tartly, "*you* don't live a million years. Because my teeth, in the fullness of time, are bound to drop out of my head, does this mean that I should not delay that calamity by prudent habits? Keep your teeth clean and you can eat longer. Keep your water clean, which means keeping your soil,—or maybe you soon won't eat at all. Come, come. Nothing can stop erosion, no. But our job, surely, is to slow down the process as much as possible. Man can and does improve on Nature for purposes of his own betterment. Are not your carefully managed forests more productive than primeval ones? And where erosion is concerned I do not ask you even to do that. I do say, for very life's sake, try to slow it down again to Nature's rate or as near to that as planned production will allow. Nature's great job, since she lighted on this planet, has been to vegetate and make fruitful; and ours is to ally ourselves with her against the stark, elemental forces of change and degradation, not a suicidal *vice versa. She* doesn't make dustbowls, it's not in her line. Only man's; greedy, reckless man's. Nor deserts, though she inherits them. So, if you call yourself a land doctor or soil conservationist, take this as your objective wherever you set to work—to reduce the rate of run-off to what it was before man came along. Believe me, you will find that a pretty ambitious target".

He rose. Our session was clearly at an end. He shuffled along with me to the entrance, his carpet slippers flapping and crunching on the floor. There he stopped me, a thin white hand on my sleeve.

"Just a moment, young man". His eyes behind their thick glasses had that twinkle again. "Men of my age have tender feet. Next time you call, pray use the door-mat more carefully. It guards me from one of the evils we were talking about—debrisation. Good-day".

TREATMENT OF RAVINES *

BY M. D. CHATURVEDI.

(Conservator of forests, land management circle, United Provinces)

Experience gained during the last thirty years in the Jamna ravines suggests that these deeply eroded clayey soils with intercalated layers of *kankar* will not support a dense crop of large size timber trees. Rotational protection from grazing during the monsoon and simple construction of *bundhs* will, however, encourage the growth of valuable fodder grasses and induce the natural regeneration of xerophytic species such as *cheonkar, babul, reonj, nim, ber* and *semal*† in suitable pockets more particularly on the deep alluvial soils collecting in valleys (1). The problem in these parts is not erosion, as is commonly believed, but that erosion is not fast enough. It has been arrested by a crazy distribution of an outcrop of *kankar*, giving the banks of the Jumna the uneven and ghastly appearance they have. There is far less area involved on either bank of the Jumna, than along the Ganges which attracts no attention. At Garhmukteshwar, for example, the Ganges has laid waste a strip six miles broad without arousing the least little protest, while the ravines at Bateshwar involving less than half the area have constituted a problem ever since 1879 when Dr. Brandis submitted his first report (2). From opportunities of observation over a series of years, the writer has come to conclusion that these ravines were never densely wooded in the past, nor are they ever likely to support anything but grass with trees dotted here and there on rich alluvium free from *kankar*. Akbar chose Agra as his capital, not because it was any more wooded or cooler than it is today, but because of the position of vantage it enjoyed to deal with the turbulent Rajput chiefs. The fact that he shot lions in the valley of the Jumna is a proof positive of the existence of open savannahs, with trees clustered here and there and not of dense forest cover which is generally associated with the habitat of tigers. And even tigers in these parts do not seem to have any particular predilection for dense forests, as their haunts in the adjoining territory of Gwalior would show. The story of desert encroaching stealthily through Agra is sheer sophistry which will not stand a moment's examination. Given the same conditions, *viz.* hard clay with intercalated *kankar* and we have the same phenomenon replicated, *e.g.* along the Gomti (Sultanpur), the Sai (Pratabgarh) along the banks of the Dhasan and its tributary Lakheri in the Jhansi district. There are no ravines along the banks of the Jumna for a distance of nearly 200 miles above Chhata. To assume that the people inhabiting the tract below Chhata were particularly improvident, indulging in reckless felling and excessive grazing which caused these ravines, is to strain one's credulity. The writer is convinced that the very physical constitution of the banks of the Jumna and not the treatment meted out to them, brought the ravines into being. Unfit for anything else, these vast areas under ravines naturally came to be heavily grazed *afterwards*, supporting vast herds of very fine cattle and by far the best variety of goats. Reckless felling and uncontrolled grazing constitute contributory factors accelerating erosion.

2. The real problem which these ravines present is not the belt of land they render unculturable, for that after all, is natural to any river in these provinces or anywhere in the world, but the sheet erosion they induce on the arable areas abutting them. The precipitous nature of their slopes, starting almost suddenly from the edge of cultivation and dropping to a depth varying from 25 to 100 feet, deprives adjoining fields of their uppermost organic layer of fertile soil and drains them dry. To

*Paper read at the Seventh Silvicultural Conference (1946), Dehra Dun, onitem 4-Contour bunding and trenching as counter erosion measures.

†See Glossary at the end.

control sheet erosion, it is necessary to impede the onrush of water from the fields lying on the high banks into the deep ravines below by—

(*a*) contour terracing and *bundhing* of fields abutting ravines ;

(*b*) maintaining a well-wooded strip on the edge of cultivation ;

(*c*) protection of vegetable cover on the slopes abutting this strip ; and

(*d*) reducing steep gradients causing rapid run-off by terracing and filling up the valleys with alluvium by the construction of *bundhs*, and plugging of the gullies in their upper reaches. Once a good *bundh* has been put up, the erosion of hillocks should be encouraged to fill up the valleys. Such alluvial dams have been thrown across by the Jamna herself at Kalpi, Chilla and other places, leaving the ravines high and dry, miles away from the bed of the river.

The success of the treatment of this belt is to be judged not from what can be grown in these ravines but by the protection afforded to the arable lands above.

3. The erosion along the high banks of the Ganges, known as the *kholas*, presents a problem different to that in the Jamna ravines. Their sandy nature and freedom from *kankar* render them more suitable for treegrowth. In these areas, temporary protection from cattle alone suffices to induce the natural regeneration of *sissoo* and *nim*. Experience gained in the Meerut district suggests that the afforestation of *kholas* on a large scale is not likely to be a difficult problem (3).

4. The total areas of *khola* and ravine lands along the Jamna, the Sai, the Gomti, and other streams in the Gangetic basin is estimated at about half a million acres. These eroded areas must be declared as 'protected' in the interest of the common weal. The objects of management should be to control the sheet erosion of the adjoining agricultural lands by developing a fairly well-wooded strip abutting the ravines. Under careful control, these areas will provide fairly good grazing and limited supplies of fuel and timber.

GLOSSARY

Common name.	*Botanical name.*
1. *Babul*	.. *Acacia arabica.*
2. *Ber*	.. *Zizyphus jujuba.*
3. *Cheonkar*	.. *Prosopis spicigera.*
4. *Nim*	.. *Azadirachta indica.*
5. *Reonj*	.. *Acacia leucophloea.*
6. *Semal*	.. *Bombax malabaricum.*

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EXTRACTS

RELATION BETWEEN NITROGEN CONSERVATION AND QUANTITY OF HUMUS OBTAINED IN MANURE PREPARATION.

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The view is sometimes advanced that in the preparation of bulky organic manures such as farmyard manure or composts, it is the humus content that is of primary importance and the fate of nitrogen, phosphoric acid, etc. is secondary, since these latter constituents are present in forms which are only partially and slowly available and could be effectively replaced by the addition of readily available mineral fertililizers. The object of this note is to point out the inter relationship that exists between the quantity of nitrogen conserved in the process of manure preparation and the quantity of humus obtained. The position in regard to phosphoric acid is not yet clear, since investigations have been meagre on this subject.

'Starter' or 'activator'

In regard to nitrogen, however, investigations have shown definitely that refuse materials of wide C/N ratios such as litter, straw, crop wastes, dung, town refuse, etc., decompose at a faster rate if a certain quantity of easily available nitrogenous material, *e.g.*, cattle urine, slaughter-house wastes, night-soil, sewage or mineral nitrogenous supplements be added so as to bring the initial C/N ratio of the compost mixture to within the range 25 to 30. All good systems of farm manure or compost preparation now proceed on this basis of decomposing mixed organic refuse low in nitrogen (the so-called carbonaceous material) by the addition of a nitrogenous supplement ('starter' or 'activator').

'Mature manure'

Numerous investigations have also definitely shown that when the above compost mixture possessing an initial C/N ratio between 25 to 30, is allowed to undergo natural decomposition by the mixed micro-flora already present in the waste materials or inoculated thereinto by added garden earth or dung emulsion, a considerable amount of heat and evolution of carbon dioxide takes place; and if conditions of moisture and aeration be optimum, the material shows a progressive lowering of the C/N ratio, which ultimately tends to stabilize itself near a level of 10. The manure is said to be 'mature' and fit for application to land when it has reached the above C/N level of 10. In certain cases, where a period of two to three months may elapse between the application of the manure to land and the sowing of crop, it would be permissible to apply manure of C/N ratio somewhat wider than 10, say between 15 and 10; but the arguments presented in the following paragraphs are applicable at any level of C/N ratio fixed for the final manure.

Balance sheet

For purposes of illustration, presuming that the farmer desires to compost his waste material down to a C/N level of 15 and that he initially started with 100 lb. (dry matter) of mixed wastes containing 30 lb. of carbon and 1 lb. of nitrogen (initial C/N ratio 30), the initial balance sheet of his compost material would be roughly as shown in column (*b*) of Table 1.

TABLE I

Balance sheets of different systems of compost making

Constituents (a)	Initial (b)	Final manure (C/N=15) No nitrogen lost (c)	50 per cent. nitrogen lost (d)	50 per cent. nitrogen lost but atmospheric nitrogen fixed (e)
	lb.	lb.	lb.	lb.
Nitrogen ..	1	1	0.5	0.5 lb.+0.1 lb. nitrogen fixed from air by 20 lb. carbon
Carbon ..	30	15	7.5	9.0
Organic matter or humus ..	75	30	15.0	18.0
Ash (residue on ignition) ..	25	25	25.0	25.0
Total dry-matter ..	100	55	40.0	43.0

If the farmer is careful enough to adopt a system of manure preparation in which no appreciable quantity of nitrogen is lost, the final balance sheet of the compost would roughly correspond to the details given in column (c) of Table I. If, however, the farmer adopts careless systems of manure preparation, which may easily involve losses of nitrogen up to 50 per cent. of the quantity initially present, the final picture would be as shown in column (d).

Humus and nitrogen

A comparison of the figures given in columns (c) and (d) shows that the quantity of humus obtained in the final manure (whether it be defined as corresponding to a C/N ratio of 15 : 1 or 10 : 1) is definitely proportional to the quantity of nitrogen conserved in the compost system. In other words, in order to obtain the greatest quantity of well-humified manure, it is necessary to avoid all sources of nitrogen loss (either by seepage into the ground in the rainy season or by volatilization into the air as ammonia or gaseous nitrogen in the dry season).

Two plausible arguments that are sometimes advanced to evade the above conclusion are : (*a*) loss of nitrogen would only widen the C/N ratio of the final manure, but the quantity of carbon and thus of humus obtained would be the same after any particular interval of time, say four months from the start of decomposition and (*b*) any nitrogen lost during compost preparation would be automatically made up by nitrogen fixation from the air, leading to a product of C/N ratio near 10 : 1 or a nitrogen content of about 2 per cent. in all cases. It would be useful to remove the misapprehension created in the minds of the farmer by the above two arguments.

As regards hypothesis (*a*) above, it is clear that if the C/N ratio of the manure is wider than 15 : 1 it has not humified completely and the quality of the manure is bound to be poor. In fact, it cannot be applied to standing crops as a top dressing, as humus of good quality can be done, nor can it be applied to land shortly before sowing crops. In both cases, it is likely to have an immediate adverse effect on the growth of the crop. It can only be applied to land some months before sowing, in order to complete the remaining stage of humification in the soil itself. In several cases, the land or climatic conditions may not be ready to receive the manure at such an early stage.

Quality of manure

In addition to the above, it may be mentioned that the work carried out by the writer indicates that the quality or 'effectiveness' of an organic manure depends, on the amount of 'mobile' nitriogen, (*e.g.* nitrogen contained in urine, night-soil, sewage or minerals) which has been 'immobilized' or converted into microbial tissues within the compost. In good quality farmyard manure or compost this fraction may represent about 30 to 50 per cent. of the total humus ; and it is easily nitrified in the soil and becomes available to crops. To the extent that such 'mobile' nitrogen is allowed to be lost during the process of manure preparation, to that extent the quality of the manure prepared (availablity of its nitrogen) is bound to suffer.

Recoupment of nitrogen

In regard to hypothesis (*b*) above, *viz.*, recoupment of nitrogen lost during composting by nitrogen fixation from the air, various investigations carried out in India have shown that the rate of nitrogen fixation averages about 3 to 5 mg. nitrogen per gram of carbon oxidized from refuse materials of the type used in compost-making. Taking the higher value of 5 mg. nitrogen fixed per gram of carbon oxidized, the balance sheet of the compost shown in column (*d*), Table I would be altered to the position shown in column (*e*).

A comparison of the data shown in columns (*d*) and (*e*) would clearly show that the quantity of nitrogen fixed from the air is so low, that it does not make up even a fraction of the large quantities that are easily lost due to careless handling. The losses are specially high in cases where the farmer takes extra trouble to collect cattle urine, dung and softer plant tissues, with a view to improving the quality of his farm manure or compost. Unless he adopts special precautions to avoid loss of nitrogen in such cases, he may easily find that all his labours have been wasted and he is in no better position finally than his easy-going brother who was content to prepare manure of poor quality and low quantity.

As regards methods for the conservation of nitrogen during manure preparation, these have been dealt with in detail by the writer elsewhere.[1]

—*Indian Farming*, Vol. VII, No. 2, February, 1946.

THE NEED FOR RESEARCH IN FORESTRY IN NEW SOUTH WALES

There are two avenues of research to be undertaken by any forestry administration, *viz* :—

(*i*) Production (or silviculture).
(*ii*) Utilisation.

The Commission has organised and established a branch to effect research along the latter avenue, *i.e.*, the Division of Wood Technology.

This division has been established on a fundamentally sound basis, of which the following broad principles are the most important :—

(1) Semi-separate existence as a division, with the Chief of the Division responsible directly to the Commission.
(2) Appointment of highly trained technical officers.
(3) Freedom of thought and action.

However, little provision has been made for the equally important aspect of forest production, and no organisation has as yet been established except for a section in Climatology-Ecology.

Owing to the long time factor in silvicultural experimentation, research in forest production cannot be deferred. The progress of research in the two fields should go hand in hand.

A glance at American annual estimates for research projects over the ten-year period 1930—1940 is illuminating.

Forest production	.. 2,075,000	dollars.
,, utilisation	.. 1,050,000	,,

The expenditure in the first instance is made up of the maintenance of a number of regional experiment stations—a procedure which could well be followed in this State.

There are two inter-related basic features of forestry research, *viz* :

(1) The complexity and extraordinary variability of the problems.
(2) The long time required to attain reliable results from experiment.

They are probably more pronounced in forestry research than in any other scientific endeavour yet undertaken, and real progress towards attaining the objectives must inevitably be graduated.

Australian silviculture is still in the pioneer stages of its development, and the inauguration of planned research constitutes an immediate necessity of considerable magnitude and vital significance.

In New South Wales species occur in a wide range of mixtures and in highly diversified environments, which renders silvicultural research a laborious undertaking which will require the compilation and analysis of large volumes of reliable data and an extensive programme of carefully planned and efficiently supervised empirical experimentation.

In the past the fulfilment of purely administrative duties, combined with a financial struggle for existence, has militated against extensive research activities. Pure research cannot effectively be conducted in conjunction with administrative work. If the two are incompatible and one must suffer, it is invariably research.

This fact cannot be too strongly emphasised. There is nothing more disheartening than finding that a certain operation was not done owing to pressure of other work, and 12 months

1 *Indian Farming*, Vol. VI, Nos. 5 and 12.

(or more) of effort must be abandoned. The investigator must live the part, become absorbed in his subject and be free from distraction.

The future welfare of research is dependent upon the selection and adequate training of unusually able and outstanding investigators.

The essential disciplines, regularity, consistent logical thinking, resource and initiative, call for far superior qualities to those required for routine administration and supervision. Keen powers of observation, of critically analysing cumulative circumstantial evidence and of accurately interpreting statistical results are necessary.

If the initiative and activities of research men are curtailed through excessive centralised direction and supervision, really able investigators cannot be secured or retained permanently.

Research itself cannot remain within fixed boundaries, but should have every degree of freedom.

No matter how well defined the original purpose, research if it is virile, will grow *in directions which are unpredictable.*

Flexibility of organisation and freedom of development are essential, and no greater encumbrance is conceivable than one which would limit this freedom.

Finally, the adequate provision of funds is vital because each individual experiment extends over several years. Even though this is difficult, since in a democracy proof against pressure exerted by economic and political exigencies seems almost unattainable, such provision must be fought for and accomplished if we are to see the light in our silvicultural problems.

—*The Bush Builder*, Vol. 3, No. 1, April 1946.

VIABILITY OF PINE SEED AFTER PROLONGED COLD STORAGE

By N. T. Mirov

(*Silviculturist, California Forest and Range Experiment Station.*)[1]

This is a report on germination of seed of 21 species of pine kept in cold storage for periods ranging from 5 to 15 years. The results show that seeds of some pines will keep for a long time without losing their viability.

Pine seeds are living organisms and they remain alive only when conditions are proper. They die when exposed to excessively high temperatures, when treated with some poisonous substances, and, in certain instances but not always, when exposed to sub-freezing temperatures.

Freshly collected pine seeds that have been dried to a low water content remain alive in storage, but their slow rate of respiration indicates little life activity. The lower the temperature at which they are stored, the slower the rate of respiration; probably it is almost stopped at temperatures approaching absolute zero (—459.6°F.). It appears from recent experiments (1, 4) that at these low temperatures many kinds of seeds can be stored indefinitely if their water content has first been reduced to a fraction of 1 percent. There are indications that pine seeds belong to this category. Under ordinary stoarge conditions, however, viability of pine seeds *gradually and steadily decreases.*

Other Investigations

Our knowledge of the viability of different species of pine is still very limited, and any information about it has both scientific and practical value.

Fancourt (3) reported germination of *Pinus pinea* seeds after 40 years of storage. Blumer (2) recorded seeds of some closed-cone species that retained viability for 30 years. Mills (6) germinated a few seeds from some 150-year-old lodgepole pine cones imbedded in the wood. Unfortunately his data are meager. Not all pine species possess such keeping quality.[2] For instance, sugar pine seeds kept in a warm room would lose viability in a short time (3 or 4 years), but sugar pine seeds kept at 40° F. for 8 years germinated to the extent of 90 percent (7).

[1]Maintained by the Forest Service, U. S. Department of Agriculture, in co-operation with the University of California at Berkeley, Calif, N. M. Effman, of this station, assisted in germination of the seed in the experiment described.

[2]There are indications that the keeping qualities of seed of different species are related to the nature of the fats (oils) they contain (8).

Conditions and Results of Experiments

Experiments with storage of conifer seeds conducted at the California Forest and Range Experiment Station for many years have recently yielded some interesting results. The seeds were stored in airtight 5-gallon tin cans at 40°F., some for as long as 15 years and all at least 5½ years. The cans were opened occasionally during the storage period when seed was needed for experiments. For the present test 100 seeds of each of 19 pine species (32 lots) were withdrawn from storage and sown in flats, and in order to assure complete germination the flats were stratified[3] at 40°F. for 3 months (7) and then moved to the greenhouse. The germination of the seeds that had been stored was then compared with records of germination tests made from the same lot of seeds shortly after they were collected. Table 1 gives the results of this test. The conditions under which the seed was stored cannot be considered the best. Occasional admittance of air into the container probably had an effect on the viability of the seed. If the cans had remained unopened throughout storage, germination would probably have been better.

Discussion of Results

The germination rate of seeds of different species of pine as reported in this paper is not the absolute maximum possible. Better results could probably have been obtained if the seeds had been better handled before they were put into storage. For instance, previous experience (7) showed that suger pine seed keeps much better than is indicated in the table. Germination of seed of a species obviously varies from one lot to another (see, for instance, in Table 1 germination percentage for ponderosa pine), depending chiefly on the handling, from harvesting cones to storing seed. In such cases the highest percentage of germination is significant, for it shows the germination that can be expected if the seed is properly handled.[4] The lower germination rate of other lots of the same species and the same age or younger shows that the seed was not handled properly.

The fact that seed of the white pine group are difficult to keep has been known to foresters for a long time (9). Therefore, the rather sharp drop in germination rate of *Pinus lambertiana* after storage was expected.

The two lots of *P. albicaulis* seed were of very poor quality, but the drop from 24 percent germination when the seeds were fresh to 17 percent after storage of seeds from the same lot was not in line with the supposedly poor keeping quality of white pine seed.

P. monticola seed kept unexpectedly well.[5] Seed of *P. aristata* and of *P. balfouriana* also kept well. It is evident, therefore, that not all white pines have perishable seed and that the poor keeping quality of sugar pine seed is perhaps an exception rather than the rule for the 5-needle group on pines.

The closed-cone pines (*P. attenuata*, *P. radiata*, and all three varieties of *P. contorta*) behaved as expected; their seed had excellent keeping quality. Cold storage is probably not necessary for seeds of this type. *P. remorata*, Santa Cruz Island pine, is a relatively new pine and not much has been known about the viability of its seed. In the present experiment its seeds germinated at least 63 percent after 7 years of storage.

Ponderosa pine seed kept better than expected. Previous experience had shown that under ordinary storage conditions it loses viability much faster than the seed of the closely related Jeffrey pine. The excellent keeping quality of ponderosa pine seed in cold storage is of practical importance, as this species is very extensively used in forest planting in the West.

Germination of the 6½-year-old Torrey pine seed was very gratifying. This interesting ornamental pine is very rare; its seed is not always obtainable. Good keeping quality of the seed may promote more extensive planting of Torrey pine.

Seeds of *P. patula* were received from Mexico in 1930. After more than 14 years of cold storage they showed a fair germination rate. These seeds were stored longer than seeds of other species in the experiment, with the possible exception of lot 623 of *P. radiata* and lot 627 of *P. lambertiana*.

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[3]Seeds of many species of pines will not show full germination capacity unless submitted to pre-germination treatment at low temperatures and given abundant moisture.

[4]By proper handling is meant harvesting ripe cones (5) extracting seed promptly, reducing moisture content to a low level (10), and putting the seed into cold storage in airtight containers as soon as possible.

[5] For *P. monticola* as for some other species, the germination percentage was higher at the end of the storage period than at the beginning, probably because of faulty technique in germinating the fresh seed. Germination capacity of pine seed cannot be improved by storage, for in storage the seeds deteriorate and germination capacity consequently decreases.

TABLE 1—GERMINATION OF DIFFERENT SPECIES OF PINE SEED AFTER PROLONGED COLD STORAGE.

Species	Serial number of lot	Origin of seed (California unless otherwise stated)	Month and year of collecting	Years and months of storage	Germination period after stratification: Beginning	Germination period after stratification: Ending	Germination after storage	Germination of fresh seed from same lot
					Days	*Days*	*Percent*	*Percent*
P. albicaulis	899	Klamath N. F.	10-1933	11-5	6	6	1	12
P. albicaulis	4411	Mt. Hood, Ore.	10-1936	8-5	8	57	17	24
P. aristata	2896	Inyo Co.	10-1935	9-5	6	24	64	72
P. attenuata	2696	Near Berkeley	3-1935	10-0	6	27	69	No data
P. balfouriana	2895	Sequoia N. P.	10-1935	9-5	5	17	72	86
P. canariensis	1083	Berkeley	12-1933	11-4	0[1]	8	13	20
P. contorta	3687	Rusian Gulch	10-1935	9-5	1	26	48	55
P. contorta bolanderi	1676	Ft. Bragg	9-1934	10-6	5	9	77	91
P. contorta var. latifolia	3887	Sequoia N. F.	10-1935	9-5	5	13	58	No data
P. coulteri	1939	Lake Arrowhead	10-1939	5-5	8	23	39	No data
P. jeffreyi	2030	Long-Bell Lbr. Co. (comm)	9-1933	11-6	5	16	24	61
P. jeffreyi	4249	Lassen N. F.	9-1936	8-6	0[1]	20	67	65
P. lambertiana[2]	3691	Klamath N. F.	10-1935	9-5	21	38	13	77
P. lambertiana[2]	4313	La Pine, Ore.	9-1936	8-6	13	32	27	73
P. lambertiana[2]	627	Sierra N. F.	9-1930	14-6	25	41	8	26[3]
P. lambertiana[2]	2013	Eldorado N. F.	10-1933	11-5	13	43	32	93
P. monticola	4414	Wind River E. F., Wash.	10-1936	8-5	7	18	66	62
P. monticola	4011	Red Mt., Wash.	10-1935	9-5	5	20	44	No data
P. patula	613	Mexico	1930	14+	8	717	39	60
P. pinaster	1073	Berkeley	11-1933	11-4	10	19	35	No data
P. pinea	1078	Berkeley	11-1933	11-4	9	27	58	No data
P. ponderosa	2010	Eldorado N. F.	10-1933	11-5	6	17	90	No data
P. ponderosa	4412	Bend, Ore.	10-1936	8-5	6	10	49	63
P. ponderosa	653	Lassen N. F.	10-1931	13-5	8	19	56	25[3]
P. ponderosa	3639	Tahoe N. Fi.	10-1933	11-5	0	17	76	72
P. ponderosa	6114	Madera Co.	10-1939	5-5	6	19	45	No data
P. radiata	4016	San Francisco	1-1935	9-3	6	14	71	No data
P. radiata	4409	Santa Cruz	10-1936	8-5	6	10	80	No data
P. radiata	2477	Santa Cruz	10-1934	10-5	5	19	36	78[3]
P. radiata	1082	Berkeley	12-1933	11-4	6	14	80	55[3]
P. radiata	623	Berkeley	10-1930	14-6	5	21	81	94[3]
P. remerata	5025	Santa Cruz Island	7-1936	8-8	7	18	54	63[3]
P. torreyana	5809	San Diego	10-1938	6-5	9	18	80	76

[1]Germinated during stratification.
[2]Better results had been obtained with germination of sugar pine seed in previous test.
[3]Not stratified.

As a whole, the results give additional evidence of the fact that viability of pine seed can be preserved for a long time if the seed is kept in airtight containers at a temperature of about 40°F.

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SCIENTIFIC METHODS OF RECORDING SOIL AND SITE CHARACTERISTICS IN THE FIELD AND COLLECTING SOIL SAMPLES FOR LABORATORY EXAMINATION

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For a proper utilization of any forest land, it is necessary, from the soil point of view, to have systematic information on the following points.

(1) Environmental factors which involve a study of the general site characteristics.

(2) Existing conditions in the soil mass which necessitate a study of the soil profile as a unit representing the history of the soil development and such factors as moisture, drainage, and existence of hard pans etc.

(3) Some idea of the physical and chemical compositions of the soil depending on the nature of the problem and local conditions of the soil. This may require the collection and packing of soil samples according to scientific methods by an officer in charge of the problem in the field.

A large part of the success of an investigation depends on how accurately the data is recorded by a research officer in the field and how the samples, if required for laboratory examination, are collected. On this also depends the correct formulation of a system of utilization of a particular locality. A true and correct recording is possible, however, only when observations are noted systematically according to some recognized method and in regular forms. Several forms of recording the soil site and profile observations have been proposed, but the ones adapted at the soil science laboratory, Oxford, appear to be the best (1). These forms with some modifications have been used with satisfactory results in the study of soil problems at the Forest Research Institute and are recommended and described here. The two forms deal with (*a*) the recording of the site characteristics of the locality and (*b*) describing the soil profile. In describing the methods of filling in each item in the forms, an attempt is made to avoid great detail which is not ordinarily required by forest officers. Changes in the original forms have also been made, wherever necessary, in order to clarify the methods of recording and to make them more suitable for Indian forest conditions. The two forms are as follows :—

FORM A
CHARACTERISTICS OF THE SITE.

Index No...........

Date.................

1. Locality of site.
2. Age of site.
3. Parent material.
4. Mode of formation.
5. Topography.
   (*i*) Main relief.
   (*ii*) Mezzo relief.

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*Paper read at the 7th Silvicultural Conference (1946), Dehra Dun, on item 10—Soil problems.

(1) Clarke, G. R. (1938). *Study of soil in the Field.* 2nd Ed.

(*iii*) Micro relief.
(*iv*) Slope.
(*v*) Aspect.
(*vi*) Altitude.

6. Drainage.
(*a*) Regional.
(*b*) Soil mass.

7. Climate.
(*a*) Rainfall.
(*b*) Wet and dry periods.
(*c*) Temperature data.
(*d*) Prevailing winds.

8. Vegetation.
(*a*) Overwood (main species) 1 2 3 etc.
Stocking percentage.
Average height.
Average girth.
(*b*) Underwood (species with stocking percentage and average heights).
(*c*) Ground cover (species with visual stocking percentage).
(*d*) Regeneration (average height and number of seedlings in 10ft.x10ft. quadrats at 5 or 6 places).
(*e*) Density of overhead canopy.

9. Man's interference.

10. F. & H. horizons.

11. Any other remarks.

FORM B

SOIL PROFILE DESCRIPTION.

Index No...........

Date...............

I. Name of horizon.
II. Depth and clarity of horizon.
III. Calcareous or noncalcareous.
IV. Colour.
V. Organic matter (form and penetration).
VI. Texture (sand, loam, clay etc).
VII. Structure.
VIII. Consistence and constitution.

(*a*) Porosity.

(*b*) Tenacity.

(*c*) Soil-water-air equilibrium (if possible).

IX. Minerals (nature, proportion and size of stones).
X. Degree of moisture.
XI. Chemical deposits (if any).
XII. Drainage characteristics.
XIII. Acidity as pH (if possible).
XIV. Root penetration.
XV. Effect of fauna.
XVI. Any other remarks.

METHOD OF RECORDING THE OBSERVATIONS

Characteristics of the site as in form A

1. *Locality of site.*—Indicate the area surveyed and the spot where the pit is examined in such a manner that it may be possible for any other person to be able to locate the place within a couple of yards. Latitude and longitude may be given, and distance and directtion from any prominent spot may be indicated. For example in the case of a pit near a hill top, the form of recording may be—"Kanhirakadavu; compt; 20, on the south slope, about 1½ chain from the top of the hill in S—direction". A sketch map may be drawn, preferably with contour lines to show elevation and with the direction of nearby streams, if any, (live or dry should be mentioned). The spot should be marked on the map as Pit 1, Pit 2, etc.

2. *Age of site:*—Here should be given some idea as to whether the soil is *mature* (*i.e.*, under stable equilibrium with respect to environment) or *unstable* (in which changes are still continuing). If one sees signs of erosion, or if the area is recently clearfelled, or if it is liable to flooding and deposition of silt or sand, it is an immature soil because the changes are still going on and the soil is not in equilibrium with its present environment. Such environmental factors should be noted. One may notice in areas where strong winds prevail that the soil is wind eroded from exposed levels and deposited in valley bottoms or cups. This should be noted because it shows that soil is till subject to changes.

3. *Parent material:*—Some soils are formed primarily from rocks *in situ*, and for these the nature of rock or parent material influences the nature of the soil. There are other soil, however, such as those in the Indo-Gangetic alluvium, which are alluvial in nature and which have lost their chemical relationship with the parent rock from which they originated. For these the parent material is unimportant.

There are other complicating factors as well regarding the nature of the parent material. Therefore the following facts should be borne in mind when noting down particulars about the parent material.

(*i*) Alluvial soils *i.e.*, soils which have been brought by river action and deposited, have little in common with the parent rock. For such soils, parent material need not be traced. All that has to be noted under this item for such soils is "Alluvial soil".

(*ii*) Sometimes drift material such as rock debris etc. is brought and deposited on top of the geological rock. This happens, for example, at the bottom of the hills. This drift material in such cases becomes the parent material of the soil and its nature must be noted. The actual geological rock below it, is not of pedological interest, though it certainly has a geological importance.

(*iii*) Soils which are actually formed from the geological rock are found mostly in south India and on the hills in north India. In the case of such soils one would observe a gradual degree of decomposition as the profile is examined, starting from the parent rock to the top soil. The nature of the geological parent material in such cases should be noted.

(*iv*) Sometimes one observe boulders of quartzose material usually rounded in shape, which may be either mixed with the soil or lying on the surface. This is usually not the parent material but an accumalation which has escaped decomposition due to its resistant nature. The proportion and average size of these stones and boulders should be noted as they modify the textural condition of the soil.

(*v*) The main point to be noted about the parent material is its calcareous or noncalcareous nature. A few drops of 25 per cent hydrochloric acid poured on a calcareous rock gives effervascence.

4. *Mode of formation.*—Here should be noted whether the soil is *in situ* (or sedentary formation), or whether it has been brought and deposited. In case of the latter, one should try to note the agency responsible for depositing the soil namely (*i*) wind, (*ii*) water (*iii*) gravity or (*iv*) ice.

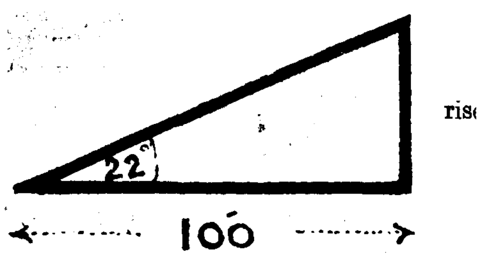
5. *Topography.—Relief of the land.—*

(*i*) First note the *Main relief, i.e.* the general lie of the land as it strikes one when he enters the area *e.g.*, hill top, hill side, low land plains, valley bottom or foot hill etc.

(*ii*) Next note the *Mezzo Relief i.e.* what strikes one at a second glance *e.g.*, gentle undulations; slopes of outcrops, whether gently sloping east, west, north or south etc.

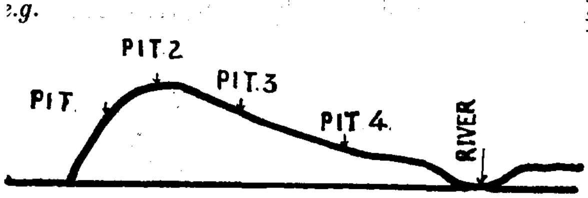
(*iii*) *Micro relief* is noted on a more minute examination and is concerned particularly with the local drainage. For example, if one examines an area commencing from the edge of a river towards the flood plains, coarse material is found to settle on the immediate edges of rivers and extends in decreasing quantity in the flood plains. This gives some idea of the extent of the deposits in areas subject to flooding. Again one may observe small erosion channels without ground cover and with coarser material left in them as compared with finer material on either side of them where the ground cover is intact. This shows liability to erosion. Any such observations are very helpful in deciding the methods of utilization.

(*iv*) *Slope.*—This may be measured with an Abney level either in degrees of inclination to the horizontal or a rise per 100 units of the horizontal distance.



RISE PER 100 UNITS OF THE HORIONTAL DISTANCE

A diagram roughly drawn to show the pit on slopes is very helpful in showing the vertical section of the topographic profile e.g.



VERTICAL SECTION OF THE TOPOGRAPHIC PROFILE

(*v*) *Aspect.*—This is the direction taken by a bearing at right angles to the feature, *e.g.* a slope facing north has a northerly aspect, while a slope facing south has a southerly aspect etc.

(*vi*) *Altitude.*—This may be measured by means of a pocket aneroid. The exact height of the spot from a basic point e.g. a river water level or the foot of the hil should also be noted.

6. *Drainage.*—Drainage may be noted under two heads namely (*A*) Regional—which is the surface drainage system of the site and (*B*) soil mass which is the drainage inside the soil mass. The latter is studied in a soil pit and is dealt with later.

Regional drainage is mainly a function of the *mezzo relief* and should be noted in such a way as to give some idea of factors like erosion, flooding, and effect on the water table etc. With this object in view the following points should be noted:—(*a*) direction, shape and size of streams if any, is important. If streams are straight and free it shows good drainage, but if they are 'locked' and meandering, it will affect the water table, and the area may not be well drained. (*b*) the shape of the valley created by a stream should be marked. If it is U-shaped with steep sides it shows mature drainage but if it is V-shaped, it is due to recent erosion by running water. (*c*) Gully or sheet erosion if going on in an area is evidenced by (*i*) small streams or dried up courses cut in V-shape with coarse material in them and perhaps with little or no vegetation and (*ii*) outwash fans of soil on lowlying sites. (*d*) the course of streams if meandering in low land areas indicate the possibility of flooding, sheet erosion or deposition of clayey material on the surface. Therefore in such areas this should be suspected and investigated. If a clayey soil is deposited on the surface it will have two effects namely (*i*) creation of drought in the subsoil mass and (*ii*) concretionary formation of calcium carbonate or sulphate in the lower horizons through material brought by transpiration currents.

(*e*) permanent water table of the areas should be noted.

7. *Climate.*—It is the local climate based on local meteorological information which should

be noted and not the general climate of the area. Under this head should be noted the monthly rainfall, direction of prevailing winds, whether the soil is protected (by forest or grass cover), or exposed, in which latter case it will be subject to erosion. It should be particularly noted whether the intense prevailing winds occur during the season when there is maximum vegetative cover or the reverse when it is at its minimum. In the latter case, intense winds may desiccate the soil and also cause wind erosion.

8. *Vegetation.*—It has been found convenient to describe vegetation over an area not less than 1 chain square and not more than 2 chains square around a spot where a soil pit is examined. Records with regard to the following are made:—

(A) Overwood:—Main species in the uppermost canopy with their number, average height and average girth (within one chain square).

(B) Underwood:—Lower story with species name, number (or percentage) and average height.

(C) Ground cover:—Different species with their percentage which is visually estimated. In certain areas, particularly under a thick canopy one notices a considerable area with "clean ground" which should also be noted. For example at a particular place one might make the following observation, "clean ground 50 per cent *Clerodendron infortunatum* 20 per cent, *Colebrookia oppositifolia* 20 per cent, miscellaneous grasses 10 per cent.

(D) Regeneration data:—Usually a forest officer is concerned only with the regeneration of the species he wants to raise on a particular site. For example in a regeneration area for *sal* (*Shorea robusta*), regeneration data for *Shorea robusta* may be given. It may be denoted by actual counts in 10 ft. square quadrats chosen at random over the area. Seedlings in the recruitment, unestablished and established stages may be noted in the case of areas which are meant to be naturally regenerated.

In natural forest areas, it is worth while noting down regeneration figures for all the principal tree species.

(E) Density of overhead canopy: Standing on a spot if one looks upwards, it is taken that the Density= 1, if one cannot see the sky, and Density=0. if one sees the clear sky without any obstruction.

Density between 0 and 1 should be judged and noted in decimal fractions as 0.2, 0.5 or 0.7 etc.

9. *Man's interference.*—Here should be filled in from enquiry any operations which interferes with the natural growth of species on a site. Such operations are burning, weeding, shrub cutting, canopy opening, fencing and cultivation etc.

Human interference with the forces of natural soil formation often effects considerable changes. For example on clearfelling a forest, some of the likely changes expected are: increased evaporation and drying of the surface soil, decreased transpiration and consequent rise in the subsoil water level, decrease in soil humus consequent on increased decomposition of organic matter and cessation of leaf fall, repression of faunal activity and incorporation of top organic matter in the subsoil mass (or the natural tilling of the soil).

1. *F. & H. horizon.*—The F- horizon is the layer of organic matter in which the botanical structure of leaves etc, is still visible. This is expected on an area where decomposition of organic litter is slow, *e.g.*, in the cold regions of the hills, or in waterlogged areas where the activity of insects is low. Sometimes a number of layers can be distinctly seen and this indicates the age of this horizon in number of years. It gives some idea of the slowness of the intensity of decomposition forces. The H-horizon is the black humus with a little mineral matter but not intimately mixed with mineral soil.

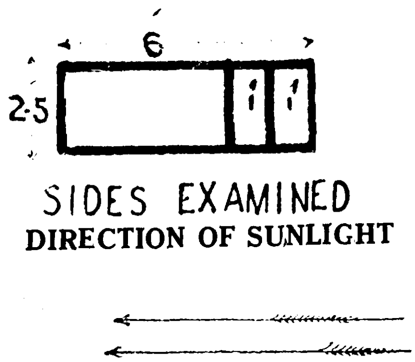
These layers are distinctly seen in podsol types of soils.

11. *Any other remarks.*—Any other facts not covered by the above questionnaire may be noted here.

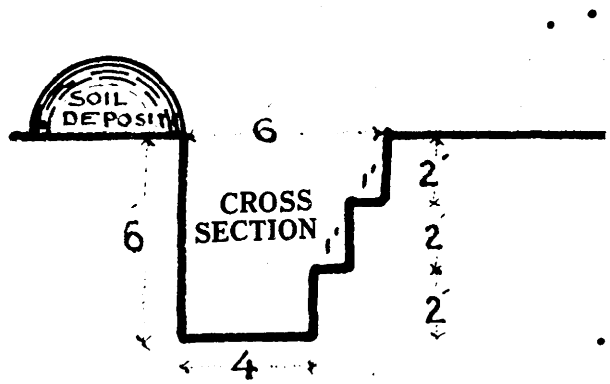
Description of soil profile as in Form B.

Different characteristics of soil are noted in a soil pit. The most convenient and

perhaps also the most economical size for a pit is 6 x 2.5 x 6 ft. with steps 1 ft. wide at every 2 ft. depth at one end as shown below:



PLAN



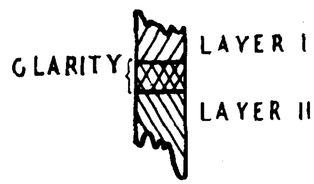
The following specifications may be followed with regard to digging the pit.

(*i*) The longer side is in the direction of the sunlight so that direct sun falls on the shorter side (*i.e.* the end of the pit) and diffused light on the longer sides. It is the latter faces which are examined, in diffused light. (*ii*) All the earth, dug out of the pit, should be deposited clear over the end of the pit (*i.e.* the shorter side opposite the steps). The top surface along the longer sides should be left clear for examination. (*iii*) At one end of the pit, steps 1ft. wide should be left at every 2 ft. depth. These are convenient for the examiner and also help the labourers in digging the pit. (*iv*) The depth of the pit depends on the nature of the investigation. It is better to dig the pit down to the parent rock if met at about 6 ft. A depth of 6 ft. is convenient for most investigation. (*v*) Examination is best done in a freshly dug pit. When it is not possible, a fresh natural surface should be exposed by scraping off about 1 ft. of the soil from the profile surface (*i.e.* wall of the pit) along the longer side, just before the examination, and then observations are made on this freshly exposed surface (as in form B on page 52).

Different items are noted according to the instruction given below. Data should be noted for all the horizons (or soil layers) individually.

I. *Name of horizon.*—It may usually not be possible in the field to distiguish the A, B & C horizons*. It is therefore more convenient to put down different layers as layers I, layer II, layer III etc. at the time of field examination.

II. *Depth and clarity of horizons (boundaries).*—The merging boundary between two horizons of the soil profile within which it is difficult to say where the upper horizon ends and the lower horizon begins is known as the clarity of the horizons.



This is denoted by the following terms.—

Sharply: where the indistinguishable boundary extends over 1 inch.

cleanly: where the indistinguishable boundry extends over 1 to 2 inches.

Merging: where indistinguishable boundary extends over more than 2 inches.

These horizons, depths and clarity are noted down in the questionnaire form as follows:—

Horizons (layers)	Layer I	Layer II	Layer III	Layer IV
Depths........	0"-21"	21"-40"	40"-50"	50"-72"
Clarity....		clearly	merging	merging

Measurements for depths of horizons are made upto the middle point of this indistinct area between two horizons, but in collecting

*Horizon A is the horizon of eluviation *i e.* the layer of soil from which certain materials are leached out *e.g.* sesquioxides (oxides of iron and aluminium) are leached out from the A horizon in podsols while in the case of laterite the reverse happens *i.e.* silica is leached out. This leached material gets deposited in the lower layer which is called illuvial horizon or B-horizon. The parent material is called the C-horizon. The F and H layers which consist mostly of organic matter (*e.g.* in Podsols) is called A_0 horizon.

soil samples (dealt with later in this note) this area is avoided.

III. *Calcareous or noncalcareous.*—Dilute hydrochloric acid (25 per cent strength) is very handy in deciding whether a soil is calcareous or not. A few drops of this solution are poured on the soil. There is effervascence in the case of a calcareous soil.

Sometimes calcium sulphate (gypsum) deposits may be found in cool humid regions in grass steppes, either in layers or pockets. It occurs in the form of soft white deposits but will show no effervascence with acid.

IV. *Colour.*—Colour is noted both in wet and dry conditions. The significance of colour is as follows:—

Black: Indicates organic matter and sometimes manganese.

Brown: Indicates iron oxide or intimate humus of the sub-soil.

Red: Indicates iron oxide in ferric state and is indicative of well aerated soil conditions.

Greenish or bluish: Indicates reduced iron oxide and shows bad aeration or water logging.

Whitish or yellowish-white: Indicates calcium carbonate, kaolin or siliceous sand.

V. *Organic matter.*—In general, three kinds of humus are distinguished namely:—

(1) Raw humus, acid humus or 'Mor': This shows the F & H horizons already defined. The pH of this humus is usually about 4.5. It is more or less pure organic matter with hardly any admixture of mineral soil with it. The boundary between this humus layer and the mineral soil (boundary A_0/A_1) is usually clearly defined (1 to 2 inches). In India such layers of acid humus are likely to be met with only in the cooler regions of the hills especially under conifers.

(2) Mild humus, neutral humus or 'mull': In this there will be an admixture of some mineral matter and it will not be so pure as 'mor'. It is more grainy and porous. The boundary between the humus layer and the mineral soil layer is not clearly defined and is merging (more than 2 inches).

(3) Intimate humus.—This type of humus gets intimately mixed with the mineral matter of the soil. Its colour may be black, brown or grey. The depth of penetration of this humus can be detected with hydrogen per oxide (per hydrol) which gives effervascence with humus. It may be pointed out that manganese also gives a black colour to the soil and its presence should be detected.†

It may be mentioned here that raw and mild humus are usually absent in tropical soils except in the cooler climate of the hills.

VI. *Texture.*—For noting down the texture of the soil, six different headings are given by Krausiuk (2) namely, clay, loam, sandy loam, loamy sand, sand and gravelly or stony. For the purpose of distinguishing texture, two simple tests may usefully be performed in the field as follows:—

(1) Take a little bit of soil and moisten it to become just sticky, and then rub it between the thumb and the forefinger.

(2) Take a bit of soil on the palm of the left hand and moisten it to become just sticky. Then try to roll it into threads and also try to bend the soil threads into rings.

The following specifications should be noted:—

Texture.	*Rubbing test.*	*Rolling test.*
(*i*) Clay.	"Very sticky and plastic".	"Gives long threads which can be bent into rings".
(*ii*) Loam.	"Plastic"	"Gives threads with difficulty but these cannot be bent into rings".
(*iii*) Sandy loam.	"Slight plasticity	"Threads form with great difficulty.
(*iv*) Loamy sand.	Non-plastic.	"Cannot be rolled into threads".
(*v*) Sand.	Forms flowing fluid mass.	Forms flowing fluid mass.
(*vi*) Gravelly or stony.	Any of the above grades but mixed with gravel (¼ to ½ inch longer axis) or stones (½ to 8 inches longer axis).	

†In order to distinguish between the black colour of the organic matter and that of manganese, take a lump of soil on the palm of the hand and pour some hydrogen per oxide (per hydrol) on it. A burning sensation shows the presence of manganese.

(2) Clarke's *Study of soil in the Field.* 2nd Ed. (1936). P. 100.

The recognition of textural grades is just a matter of practice with different soils and no short cut can be suggested. The above technique is, however, simple and can be easily mastered with a little practice.

VII. *Structure.*—It is noted that tropical soils in general do not show clearly defined structure, and whatever structure exists, its recording becomes very difficult especially because we have no agreed nomenclature in this country for such soils. The subject is under consideration by the Imperial Council of Agricultural Research. No attempt should be made by a research officer to put down a structure unless he is definite about it, and in case no definite structure is detected it may be stated as such.

VIII. *Constitution.*

(1) Porosity: Note whether the soil is porous (good soil) or fissured and cracked alkaline or saline soil or very clayey soil without grains. If porous, is it sandy, spongy, cavernous or fine grainy?

(2) Compactness: Four grades are suggested which are easily and best detected while the pit is being dug. These grades are:—

- (*i*) Very compact: spade cannot work, a crow bar is required.
- (*ii*) Compact: spade works with difficulty.
- (*iii*) Loose: spade works easily.
- (*iv*) Crumbling: No cementation as in sand.

(3) Soil—moisture—air equilibrium: Weights are taken of soil columns 6 inches long, taken with a soil sampler in wet and dry conditions, and the percentages of soil, water and air are calculated by volume. This gives an idea of the pore space of the soil, Compression of soil, while driving the soil sampler into the soil, may also be usefully noted.

IX. *Minerals* (*nature of stones*). The following should be noted:—

(A) Shape of stones: Whether they are angular, sub-angular or rounded?

(B) Size: Note approximately whether they are gravel (longer axis 1/4 inch), coarse gravel (longer axis 1/4 to 1/2 inch), small stones (longer axis 1/2 to 1 inch), medium stones (longer axis 1 to 4 inches), large stones (longer axis 4 to 8 inches) or boulders (longer axis greater than 8 inches). The predominating size should be noted.

(C) Proportion: (*i*) Stoneless:— no stones at all mixed with the soil.

- (*ii*) Few: When there is no likelihood of of any visible effect on the soil mass or utilization due to stones or gravel etc.
- (*iii*) Frequent: When there is a likelihood of some effect on the soil mass or utilization.
- (*iv*) Dominant: when there are more stones than soil.

X. *Degree of moisture.*—This may be indicated in the field by the following notations (3) for most of the soils.

O means	.. Air dry.
+ means	.. Weekly moist
++ means	.. Moist but changes colour on further wetting.
+++ means	.. No change of colour on further wetting (moisture at field saturation capacity or at moisture equivalent value). There is enough available moisture at this stage but no bad aeration.
++++ means	.. Water logged.

XI. *Chemical deposits* (*if any*).—Note the nature and form if such deposits are met with. For example lime concretions, salts either crystalline or as efflorescence (as in saline and alkaline soils), deposits of gypsum, or black grains of oxide of manganese (as in laterite soils sometimes), etc.

XII. *Drainage.*—This must be noted under the following heads:—

- (*i*) Excessive: When there is a likelihood of a considerable loss of soil nutrients but an inadequate retention of rain water as in very sandy soils. Such soils may be subject to drought.

(3) *Loc. Cit.* p. 158.

(*ii*) Free: Satisfactory percolation as well as an adequate retention of moisture and nutrients (esp. exchangeable bases) by soil as in a sandy loam. Such soils may or may not be subject to drought depending on the rainfall and its seasonal distribution.

(*iii*) Imperfect: Very dense horizons but no water logging.

(*iv*) Impeded: Impermeable horizons which are likely to produce water logginga nd anaerobic conditions. This state of drainage can also be brought about by a high water table or an impermeable layer of soil at some depth in an area with high rainfall.

It may be pointed out that the colour of the soil also gives some indication of the drainage conditions to some extent. The following may be noted in this connection:—

(*i*) Bright colours (red or reddish brown); indicate well-drained conditions.

(*ii*) Dull colours (pale yellow, bluish or greenish colour) indicate imperfect drainage.

(*iii*) Mottlings (red, blue, green etc). indicate a rise and fall of the water table in a particular zone. One should, however, be careful in noting down this characteristic because a disintegrating rock also shows a mottling effect to some extent.

XIII. *Acidity as pH*.—This may be determined by means of any field outfit. As is well known, pH is the negative logarithm of the hydrogen ion concentration *i.e.* $pH = 1/\log [H] = \log^{-1}[H]$.

Neutral condition is indicated by pH=7. pH less than 7 indicates acidic condition whereas pH more than 7 indicates alkaline condition.

Several methods of determining pH of soils are recommended. The simplest method is to prepare a soil solution by mixing 10 c. c. of a normal potassium chloride solution* with 2.5 gm. of soil in a neutral glass sample tube, allowing the soil to settle down and then determining the pH of the supernatent solution by means of an indicator colourimetrically. The indicators used are solutions of certain dyes which change colour within certain pH ranges. One such indicator is the B.D.H. Univeral Indicator (prepared by the British Drug Houses, London) which changes to different colours from pH 4—11. The colours would indicate the approximate pH values of the solution (which is taken as the pH of the soil).

As indicated above, the ratio of the solution (N-Pot. Chloride solution) to the soil is 10:2.5 by weight which was arbitrarily fixed by the Internatinoal Society of Soil Science. In the field, however, it is not possible to do the weighings, so that a simple method was devised at the Forest Research Insitute, Dehra Dun. A glass sample tube of neutral glass is taken with two marks at 10 c.c. and 11.5 c.c. N-Pot Chloride solution is filled to 10 c.c. mark (upper meniscus taken). Then the soil of which the pH is to be determined is poured into the sample tube till the solution rises to the mark 11.5 c.c. This adds nearly 2.5 gm. of the soil required. Care is taken that the soil is freed from stones and gravel either by hand picking or preferably by sieving through a 2 mm. sieve. The sample tube is shaken to mix the soil and solution and allowed to settle. The pH of the supernatent liquid is then determined by mixing the requisite quantity of B.D.H. Universal Indicator with the soil solution on a piece of porcelain (neutral porcelain) by means of a dropper. The colour developed indicates the pH of the soil. Accuracy is nealy 0.5 of the pH scale. For greater accuracy, specific indicators specified for narrow pH ranges are employed. The method is simple and does not require any elaborate equipment. All that is wanted is (*i*) a neutral glass sample tube 6 in. x $\frac{3}{4}$ in. size. (*ii*) a small bottle of B.D.H. Universal Indicator; (*iii*) a dropping pipette (neutral glass); and (*iv*) a piece of neutral porcelain. All these things can be put in a small bcx which can be put in the pocket and carried to the field.

XIV. *Root penetration*.—The following should be noted:—

(1) Depth of root penetration.

*7.46 gm. of potassium chloride (chemically pure) dissolved in 100 c.c. of distilled water makes a normal solution of this salt.

(2) Do the roots get lateral at any depth instead of penetrating straight down? This shows conditions of bad drainage at that particular point in the depth, because roots dislike, penetrating into an ill-drained soil.

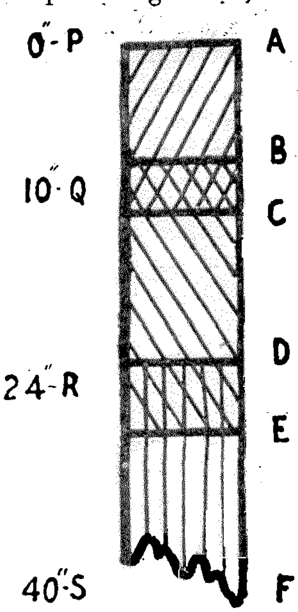
(3) If the above condition is observed, one might perhaps notice that soil near the roots is greenish or bluish. Roots in an attempt to obtain oxygen reduce the oxides of iron in the soil which give the latter this colour.

XV. *Effect of fauna.*—The existence of fauna such as termites and ants (in hotter climates) and earth worms is a sign of fertile and well aerated soil. The depth of their activity as indicated by the existence of burrowing holes etc. should be noted.

XVI. *Any other remarks.*—Whatever has not been covered by the above questionnaire may be noted here.

Method of collecting soil samples for laboratory examination

It is best to collect soil samples soon after the pit is dug. This, however may not always be possible. In that case about one foot of the soil is scraped off from the face of the profile to expose a fresh surface. Samples of soil are collected from each horizon in the profile as seen in a soil pit. Each horizon is marked by means of pegs. Collection of soil samples is then made from each horizon, leaving out the merging zones between the horizon boundaries. For example in the sketch shown on the left



the horizons and depths should be noted as follows*:

*Name of horizon	Depths.	
I	II	III etc.
0"—10"	10"—24"	24"—40" etc.

measurements being made to the middle point of each merging zone (middle points being Q, R etc., in this case). The actual soil samples are collected from the areas AB, CD, EF etc., neglecting the merging zones BC DF, etc. (4).

For collecting soil samples, a spade is fixed at the base of each horizon, a little above the merging zone (*e.g.* in case of top horizon PQ, the spade is fixed at B or a little above B). Soil is then dug out by means of a pick-axe with a small handle or a knife in such a manner that big lumps collect on the spade. Digging is done over the entire horizon leaving out the merging zone. The soil on the spade is transferred to a cloth bag about 12 x 9 inches in size. Nearly 2 to 3 lbs of soil is enough.

In case horizons are not seen or even if they are not clearly visible, soil samples may be collected at definite depths. In fact it is advisable that even if one sees the horizons, soil samples at definite depths may also be collected, along with the horizon samples, because sometimes the change in soil from top to bottom is very gradual. Generally the officer on spot can best decide the most suitable depths at which to collect soil samples but it is usually seen that a soil varies most in the top regions while there is less change as one goes deeper down. Therefore the following depths may be found most suitable for most of the soils:—

(*i*) 0 to 6 ins., (*ii*) 6 to 12 ins., (*iii*) 12 to 24 ins., (*iv*) 24 to 48 ins., and (*v*) 48 to 72 ins. measurements being always made from the top of the pit.

Soil samples from the individual pits should be kept separate. The old method of preparing composite samples by mixing soil samples of a particular depth from several pits has now been abandoned by most workers (5).

*(N. B.). Points to which measurements are made for depths of horizons are Q, R. etc. which are middle points of the merging zones BC, DE etc., between one horizon and another. Pegs are put at A,B,C,D,E, etc., while marking the horizon boundaries.

(4) Piper, C.S. (1944). "Soil & Plant Analysis" (A monograph from the Waite Agric. Res. Inst. Published by the Univ. of Adelaide (Australia).

(5) *Loc. cit.* p. 1

Particulars of soils should be noted on a cardboard label attached to the bag and also on a paper which should be folded and put inside the bag along with the soil the following particulars should be noted on the labels.

Date of collection No. of the Pit.

Index No.

Depth.........(*e.g.* 0″---6″, 12″—24″ etc. measured from top).

No. of the horizon (as I, II etc. counted from top.)

Immediately after bringing the soil samples to the place from where they are to be despatched, the samples should be spread on sheets of paper and dried in shade. After air drying, the samples are refilled into their respective bags, the paper labels carefully compared with the label on the bags and put inside the bags along with the soil and the bags are fastened up. The sample bags are then despached to the laboratory for examination.

BANE

(FLEA-BANE, INSECT-BANE, MOSQUITO-BANE, BUG-BANE ETC.)

FOREWORD—We have recently received through the Central Silviculturist, Forest Research Institute, Dehra Dun, a copy of a most interesting article by an army doctor written ninety years ago. It is extracted from the *Cyclopaedia of India and of Eastern and Southern Asia, Commercial, Industrial and Scientific,* **Edited by Edward Balfour, L.R.C.S.E., Surgeon, Madras Army, Published in Madras by the Scottish Press, 1857.**

In view of the vast amount of work which was done during the recent World War II on the subject of insecticides, we reproduce the article below and we are sure it will interest readers.—*Ed.*

"There are few residents in India who have not suffered from the attacks of insects, and from their depredations; and it may be useful to be aware that many substances are known to possess properties, the influence of which is avoided by noxious creatures and annoying vermin. It is supposed that some species of *ants* will drive out the termite or white ants, but this point is not yet fully ascertained. The whole family of *Apocynaceae* termed dogbanes are truly so. One of them (the *Nerium piscidium*) common in the Khossia or Sylhet mountains, and the bark of which contains much useful fibre, proves deadly to fishes. *Dogs* refuse to sleep on rugs beneath which mint has been placed, and this simple plant thus affords a good means of ensuring cleanliness. *Deer* refuse to approach crops, in which the safflower (*Carthamus tinctorious*), has been intermixed. White mustard, sown round vegetables, as the cabbage, prevents the inroads of *caterpillars*. *Snakes* are said to avoid the fennel plant, as well as all places where the fennel seed (*Nigella sativa*) is strewed. The rasped wood of the oleander is employed as rats-bane. To destroy flies in European countries, a decoction of quassia, placed in a plate, is frequently had recourse to. In southern India, plants of the *ghigowar* or *kulbunda*, the *Aloe perfoliata*, are suspended with their roots upwards with a longitudinal incision in each leaf, to permit the aroma of the juice to become apparent and disperse musquitos from the room. Flies, fleas and musquitos, avoid rooms in which branches of pennyroyal have been suspended. Fortune mentions that the Chinese expel musquitos from their rooms and boats, by the smoke of pastilles. In India they are smoked out by burning chips of wood. A species of ant, *Formica smaragdina*, well known in Malabar, and the wooded parts of India, is employed in the North West Provinces to destroy the nests of wasps that have established themselves in a house. In this case they are said to destroy all the wasps, but become so infuriated that their own indiscriminate attacks are nearly as bad as those of their foes. Honigberger states that a twig of the walnut tree (*Juglans regia*) is kept in a room, as a means of dispelling flies. The same author mentions that bitter almonds are poisonous to wild beasts; and when writing on the *Conyza anthelmintica* (*Veronica anthelmintica, Serratula anthelmintica*) he adds that when flea-bane is roasted,

flies take to flight, and when sprinkled on the floor, fleas disappear... Dr. Hooker mentions that *Clerodendron* leaves, bruised, are used to kill vermin, flyblows etc., in cattle. The *Inula pulicaria*, or Flea-bane, a common road-side plant in Britain, strewed or burned in any place, destroys gnats and fleas: and the same properties are attributed to the common Ox-eye daisy of England (*Chrysanthemum leucanthemum*). A powder, the poudre Mismaque, is sold in Paris, in boxes at from two to twenty francs, warranted effectual for destroying immediately, bugs, fleas, ants, lice, black beetles, caterpillars and all insects. "Comomille rouge", the beautiful red Pyrethrum (*P. carneum* formerly *Chrysanthemum coccineum*) in England, a pretty garden ornamental flower, is a dread enemy to the Caucasian, Persian, Koordish and Russian fleas. It is prepared from the flower heads of the plant which when dried and crushed, form the famous flea powder. When used by being sprinkled in beds, etc., it kills all disagreeable and hurtful insects, and a small quantity of the spirit distilled from it, destroys insects in green houses, or can be applied to vegetable life in the open air against green fly, house fly, etc., without injuring the plants. A half teaspoonful of the powder sprinkled between the sheets will effectually dispel all fleas, bugs and lice, gnats and musquitos, and it is said also to destroy maggots which breed in wounds, a property which the valuable *Decamulle* gum of India, the gum of the *Gardenia lucida*, also possesses. More than twenty villages in the district of Alexandropol are occupied in the cultivation of the red chamomile, and thirty-five tons of this flea powder are manufactured annually for Russian use, in Trans-Caucasia alone, being equal to about 40,000 kilos of powder from 80 millions of pounds weight of fresh flowers. The red Pyrethrum is now largely cultivated in various circles and Governments of Southern Russia. The flower heads lose vastly in weight by drying, and to get one pound of dried flowers, 1,000 pounds of the fresh are required. It begins to flower in June and lasts more than a month. The flowers are plucked in dry weather, and a good collector will pluck 30 to 80 pounds daily. They should be dried in the shade, and care taken to stir them frequently. The Pyrethrum powder, seems the same as the well-known *Pireoti* of Koordistan, is largely imported into Turkey, and was lately greatly used in the barracks and hospitals of Turkey and the Crimea, by the English and French officers: it accomplishes very effectually the destruction of fleas, etc. Mr. H. H. Calvert, at first, considered the plant might be a *Pulicaria*, a *Matricaria*, or *Anthemis*; but, that the Piroti is the powder of the half ripe flower heads of *Pyrethrum carneum*, there now seems no doubt. The *Pyrethrum carneum* does not grow in India, but its introduction merits favourable consideration. The property it possesses of dispersing the vermin which infest beds and bedrooms, probably depends on the pungent oil it contains; but until its introduction into India, attention might be directed to other species of pyrethrum, and to the allied genus of chrysanthemum, or Christmas flower, as likely to contain an oil with properties similar to the flea-bane. The Rev. Mr. Mason mentions two species of pyrethrum, *P. indicum*, and P. *sinense*, as growing in the Tenasserim Provinces. The odour of the common fever few, of Britain ,*P. parthenium*, is peculiarly disagreeable to bees, and these insects may easily be kept at a distance by a person carrying a handful of the flower heads: perhaps also, the "*akarakarum*" of India, the *Pyrethrum officinale* or common pellitory, may have equal power. Allusion has been made to the well known Chrysanthemum, Christmas flower, as likely to possess an oil of similar character, and perhaps possessing similar properties to that of pyrethrum. One species, the *C. indicum*, the common *Gool Dawadee*, and of which there are several varieties, grows all over India, and is at any rate worth a trial, as indeed is every other unexpensive suggestion, which holds out a promise of increasing the comforts of the sleeping room. It is the habit of the natives of India, to suspend in their houses a few branches of the milk hedge (*Euphorbia tirucalli*) to destroy fleas. They likewise make pastilles containing sulphate of copper, which, when burned, destroy bugs, musquitos and fleas, using three or four in a day. The *sherifa* or custard apple seed disperses vermin. Flies are reported never to settle on the tree or its fruit, though ants will attack both. Bugs have a great antipathy to the leaves of the custard apple, and instantly quit a bed in which they are placed, and Dr. Irvine

mentions that *Babui*, the roots of *Ocymum pilosum*, have the same effect. The leaves of the American species of the sweet flag are said to be noxious to insects and to be never eaten by cattle. (Sweet flag, Eng; *Vaesamboo*, Tam; *Vudya*, Tel; *Vyamboo* or *Vashamboo*, Mal; *Shwet-Buch*, Beng: *Buch*, Duk.) The Gum Anime, is a protection against the attacks of insects; and colocynth is useful for protecting shawls and feathers against their inroads. Camphor-wood is valuable for the construction of chests and almirahs, as its powerful odour protects the contents from the ravages of white ants and other insects. The leaves of the various *Margosa* trees, *Melia* and *Azaderachta*, dried and kept in books, are much used by the people of India to preserve them from the attacks of insects. To prevent injury to furs, feathers, books papers and clothes that are lodged in trunks, book cases, etc., it is useful to place along with them small packets of camphor; or little cups of camphor dissolved in alcohol; packets of the seeds of the small fennel flower, *Nigella sativa, the kalajira* of the bazars; pieces of the roots of the *Aconitum ferox*, the dreadful "*bish*"; *Ati Singeea bish* or *bishnak* of the bazars, may also be used, but its highly poisonous effects on animal life, require its use to be had recourse to with the greatest precautions. Insects are very destructive to books in India; and the pastes or gums employed in the bindings, form special objects for the attacks of certain tribes: it may be useful to be known, therefore, that insects refuse to attack the gum of the cashewnut fruit, and that a little sulphate of copper or blue vitriol mixed with the rice or flour paste, used for joining papers, very effectually keeps these destructive pests at a distance. The leaves also of the *Justicia gandarussa*, dried and powdered, are often used as a preservative to keep insects from books."

WANTED: CONSERVATORS OF LAND

By J. W. Nicholson, C.I.E., I.F.S.

(*Conservator of Forests, Orissa*)

In 1939 I wrote a paper on "Erosion problems in Orissa" which was originally intended for a meeting of the board of forestry but, as that meeting was postponed, it was included instead amongst the agenda of the fifth silvicultural conference. In that paper I drew attention to the need for a radical re-organisation of land administration in India. I pointed out that whereas the forests of India had been placed in charge of technical department, non—forest lands had been regarded merely as sources of revenue. They had never been placed under the charge of estate managers trained to make the best rational use of the lands entrusted to their care, with the result, which enlightened nationalists are becoming increasingly conscious of, that through faulty systems of cultivation, overgrazing and other land abuses, serious erosion is occurring and soil fertility being lost over a great part of the country, I mentioned that in my own province, Orissa, my proposal to place government estates under the management of the agricultural department had been turned down on the grounds of expense but that instead it had been agreed that *tahsildars* should in future be given some agricultural training, and that applications for land leases should be scrutinised by the agricultural department. So far nothing however has been done to implement this decision. On the contrary, under the stimulus of the "Grow More Food Campaign" more land than ever, including forest land, has been brought under forms of temporary cultivation which can only lead to serious loss of fertility.

At the recently held senior officers conference papers were contributed on the subject of "the functions of the forest department *vis-a-vis* the agricultural department with regard to soil conservation." In a paper submitted by the inspector general of forests he pointed out that ordinary departmental machinery was inadequate for the planning of a countryside and that plans should be prepared and executed by a team of experts under a suitable directive which might be a separate department or a board which would function as a department. Whether a separate department should be formed or not must necessarily depend on the size of a province and its problems. In a small province such as Orissa one is not likely to

prove justifiable. There was general agreement amongst the authors of papers that land management departments or boards of composite character should be established, Bombay having already given a lead to other provinces in this respect.

So far as I am aware the proposed land management departments or boards are intended to function mainly in respect of soil conservation problems. There has been no expressed intention that they should be entrusted with the administration of the whole provincial land estate. In my above referred to paper I contemplated the management by the agricultural department of government estates only and I also drew attention to the difficulty in enforcing particular methods of cultivation in the case of occupancy holdings. The situation is now changing. In most provinces political opinion is strongly in favour of the abolition of *zamindaris*. The absorption of *zamindaris* into government estates involves that the proper management of such estates will become a matter of immensely greater importance than at present. Further, if legislation can be introduced to permit of the appropriation of *zamindaris* it can also be introuced so as empower government to control cultivation in occupancy holdings and to consolidate the same.

Surely now is the time to abolish an archaic system of land administration? Scrap the revenue department and set up in its place a department of lands. Let that department be in sole charge of all lands, other than forest, and the authority responsible for the welfare of the cultivators and rural reconstruction. Let it be organised on the same lines as the forest department. What more apt titles than "Conservator of lands", "Assistant Conservator, lands", "Divisional or District land Officer" etc.? Given that it is now recognised that each province must have some organisation to tackle land planning and soil conservation problems there seems no reason why the setting up of a land department should prove an expensive luxury. District Officers these days are overburdened with work. Although land revenue administration is now far from being their paramount job, it does take up some of their time and, if relieved of it, they would be able to perform their other duties more efficiently. Existing revenue officers such as *tahsildars*, would be absorbed in the new land department and they and other land officers would be given special legal powers as are accorded to forest officers.

It will have been noted that I have excluded forest land from the orbit of the land department. The reason is obvious. Forestry and agriculture are far too vast subjects to permit of officers being adequately trained in both. Efficient management of lands and forests demands that each should be administered by officers who have received the highest possible technical training. Coordination of their activities will come from above. The two departments should be under the charge of a minister of lands and forests who could be suitably assisted by a composite land utilisation board of experts and non-officials. In provinces where separate soil conservation service is considered necessary, that service would come under the control of the same minister and board.

I am aware that my proposals are revolutionary and that they are likely to be ill-received by administrative die-hards unimbued with that desire for progress which is the mainspring of both involution and evolution. India is on the threshold of a new life. Her prosperity depends ultimately on the land. Her administrators are not hidebound by past traditions. May they fearlessly leave no road unexplored which may lead to the conservation and development of India's greatest asset—her soil.

SOIL EROSION SURVEY AND CONSERVATION WORKING PLANS *

By R. Maclagan Gorrie, D. Sc.

(Conservator of Forests, Soil Conservation Circle, Punjab).

The objectives of any erosion assessment may be stated as follows:—

(1) to present an accurate picture of erosion damage and the pace at which it is occurring.

(2) to build up enough data to produce a provincial map of seriously eroding areas for the guidance of the Land Utilisation Board.

(3) more detailed information for each catchment as a basis for a catchment plan for each major stream or district.

(4) the application of these data to village working schemes for forest and waste land.

Experience so far gained in the Punjab indicates that once some detailed knowledge of erosion conditions has been tabulated and mapped for a given catchment or district this can be modified or generalised to present a provincial picture, but that working in reverse from generalisations to particulars is not so easy because eash fresh demand for detail can only be met by more intensive reassessments. On the other hand detailed assessments in the first instance represent an investment in time and highly trained staff which can ill be spared from the more obvious and pressing problems of orthodox forest conservancy, the revision of expired forest working plans, and the leeway of wartime disorganisation and deterioration in the moral fibre of the entire departmental staff. Most provinces want to know just how far they should commit themselves in terms of allocating staff and funds to erosion surveys, and our experience in the Punjab may therefore be of some interest.

Detailed Erosion Intensity Survey of the Uhl Catchment

In the summer of 1936 a detailed survey of erosion conditions in the catchment area of the Uhl river was undertaken at the request of the Chief Engineer, Electricity, Punjab, as some anxiety has been felt for the safety of the project owing to the occurrence of uncontrollable floods in summer and a very poor free-water flow in winter.

The catchment area of the Uhl and Lambadag rivers lies behind the barrier of the outer Dhauladhar range in Kangra, and their water is brought by tunnel through this range from Brot to Jogindarnagar where they are utilised for power. Their combined catchment area is about 150 square miles, out of which only 12 square miles is in Mandi State and the rest in Kangra district. A previous examination of the ground had shown that the two chief sources of serious erosion were (*a*) intinerant graziers' thoroughfares through alpine pastures and (*b*) shifting cultivation and bad cultivation methods throughout the village lands. To these the chief engineer added a third, namely the danger of temporary stoppage of streams by mud flows, earth screes, rock falls, and collapse of snow bridges. Our survey ultimately focussed attention upon the ground below the 9,000 ft. contour, as it showed that it is from this lower belt, mostly farmland, that the important winter runoff is obtained when all the higher slopes are frost bound.

A 4 inch map tracing of the entire area was prepared from existing survey sheets. The 4″ scale allows a ¼ square inch as a unit for estimating erosion on the map equalling 10 acres on the ground, and this proved to be sufficiently detailed for our purpose, though actually many of the forest and alpine areas were described in much larger units of area (*vide map on page* 67). Description was confined to a system of indicator figures entered on the field map, as per examples given below. Full field notes were also kept in a notebook to supplement any local inhabitants' knowledge of grazing intensity, either permanent or seasonal, verbal accounts of landslips, torrent action floods, persistence of snow bridges, etc. The divisional forest staff supplied information about grazing incidence and how the actual incidence

*Paper read at the 7th Silvicultural Conference (1946), Dehra Dun, on item 6—The technique of soil erosion surveys.

compares with what is laid down in the forest settlement for the area. Field notes were also made on what steps should be taken in effecting soil conservation measures. The work occupied 1 month of my own time and 2 months of a senior forest ranger with a small staff of 1 forester and 3 guards.

The indicator figures were modified as experience in the field showed that this was desirable. Any changes made have to be applied retrospectively to previous work so that the whole survey must be maintained on the same basis, and time spent on the selection of datum subheads and range of assessment is never wasted. The headings actually used were as follows:—

(1) Top Line

MAIN HEADS FOR EROSION SURVEY DATA

C. = Cultivated	)
F. = Forest	)
G. = Grassland	) Plus the follow-
R. = Rock or cliff	) ing figures
S. = Glaciers and snow	) used as nume-
bridges	) rators.
U. = Unstable screes	)

Sub-divisions under C = Cultivated.

1st digit. Basis, 1 = Permanent, 2 = Periodic, 3 = Newly broken to plough, 4 = Abandoned.

2nd digit. Condition of terracing, 1 to 9 in efficiency, descending scale, 9 being the worst potato fields, practically unterraced on excessively steep slopes.

3rd digit. Crops, 1 = Rice, 2 = Wheat or barley, 3 = Gram or pulse, 4 = Potatoes, 5 = Maize.

Sub-division under F. = Forest.

1st digit. Forest types.

1. Ban oak
2. Kharsu oak
3. Miscellaneous broad-leaved scrub
4. Deodar
5. *Kail*
6. Spruce and fir
7. *Chil*

2nd digit. Soil cover and condition.

1. Mainly grass
2. Mainly grass heavily grazed
3. Mainly herbs or ferns
4. Mainly heavily grazed herbs
5. Mainly shrubs
6. Mainly heavily browsed shrubs
7. Mainly cut or lopped shrubs
8. Leaf litter
9. No plant or little cover

3rd digit. Condition of canopy.

1. Canopy completely ruined by lopping, felling and fire etc.

2-8. Intermediate stages (values same as ordinary forest canopy percentages).

9. Canopy complete.

Sub-divisions under G. = Grassland.

1st digit. Type. 1. Village waste, 2. Private grazing grounds, 3. Alpine pastures.

2nd digit. Use. 1. Permanent grazing, 2, Seasonal grazing, 3. Grass-cutting.

3rd digit. Incidence. 1. Excess of buffaloes, 2. Excess of cattle, 3. Excess of sheep and goats, 4. Excess of all stock.

Sub-division R. S. andu.

No sub-division.

(2) Bottom Line

DENOMINATOR VALUES FOR ALL ABOVE TYPES—

1st digit. Angle or slope; 1 to 9 in 10° units with 9 = 900 vertical. (Subsequent experience shows that for average hill country the amount of land steeper than 30° is so small that a better range of slope could be booked in percentages instead of degrees, see below).

2nd digit. Porosity of soil 1 to 9 in terms of capacity to absorb moisture.

3rd digit. Soil types

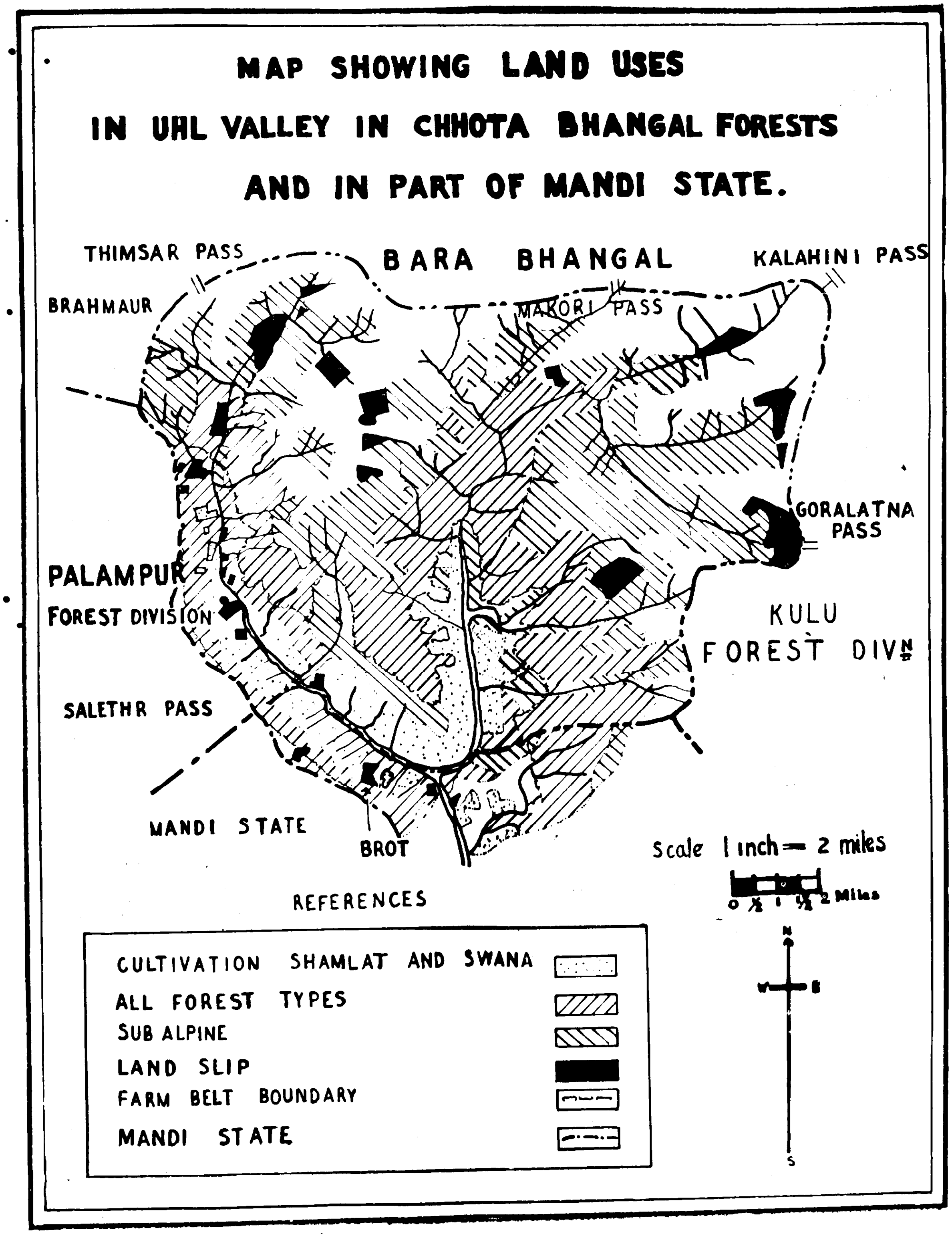
1. Compact clay
2. Clay loam
3. Slaty loam
4. Sandy loam
5. Sand
6. Boulder, pebbles, or scree
7. Boulder clay or conglomerate
8. Exposed gneiss or sheet rock
9. Not allotted, to be used if necessary for any local type of soil.

4th digit. Erosiveness of soil; 1 to 9 in terms of liability to wash.

5th digit. Liability to landslip owing to torrent glacier or snow-bed action.

Description of Torrent Mouths.—separate notes were kept on the following points as being of value in assessing deterioration or improvement in subsequent resurveys:—

Area of debris cone (talus slope).
Slope of debris cone.
Signs of recent action.


MAP SHOWING LAND USES
IN UHL VALLEY IN CHHOTA BHANGAL FORESTS
AND IN PART OF MANDI STATE.
THIMSAR PASS
BARA BHANGAL
KALAHINI PASS
BRAHMAUR
MAKORI PASS
GORALATNA PASS
PALAMPUR
FOREST DIVISION
KULU
FOREST DIVN
SALETHR PASS
MANDI STATE
BROT
Scale 1 inch = 2 miles
0 ½ 1 1½ 2 Miles
REFERENCES
CULTIVATION SHAMLAT AND SWANA
ALL FOREST TYPES
SUB ALPINE
LAND SLIP
FARM BELT BOUNDARY
MANDI STATE
N
W
E
S

Presence of slips in upper reaches.
Undercutting in upper reaches.
Snow bridges, glacier action or snow slides.

Examples.—

1. $\frac{\text{C.194}}{\text{38740}}$ Village cultivation, permanently but very badly terraced, under potato crop: angle of slope 30°, porosity high, very friable and easily eroded loam; no danger of landslip.
2. $\frac{\text{F.644}}{\text{48230}}$ Spruce forest, herb cover grazed, canopy very open from lopping: slope 40°, soil very porous but not friable or easily eroded owing to needle and litter and mould.
3. $\frac{\text{G.144}}{\text{22350}}$ Village grazing common under permanent use, heavily grazed by all cattle, average slope 20°, porosity poor, friable shaley soil, scattered browsed shrubs, scanty grass: condition stable, but sheet erosion active.
4. $\frac{\text{G.323}}{\text{24194}}$ Alpine pasture on a graziers' route heavily used seasonally; 20° slope, fairly porous : shallow sand overlying partly exposed gneiss, crumbling and very easily eroded.
5. $\frac{\text{U.}}{\text{62629}}$ Steep bank of uncompacted torrent debris liable to slip *en masse.*

For the booking of slopes in the first digit of the denominator I would suggest a better unit for the common range of slopes would be *percentage rather than angle.* The range of 9 units could be operated best by using 9 as the steepest slope likely to be met in a given area viz:—

Unit for 1st digit	Foothills & rolling uplands	High hills
	Level to 1 in 100	Level to 3 in 100
2	1 in 100 to 3 in 100	3 in 100 to 6 in 100
3	3 in 100 to 6 in 100	6 in 100 to 10 in 100
4	6 in 100 to 8 in 100	10 in 100 to 12 in 100
5	9 in 100 to 10 in 100	12 in 100 to 15 in 100
6	10 in 100 to 12 in 100	15 in 100 to 20 in 100
7	12 in 100 to 15 in 100	20 in 100 to 40 in 100
8	15 in 100 to 20 in 100	40 in 100 to 60 in 100
9	Over 20 in 100	Over 60 in 100

This grouping would incidentally match the range of slopes on which the various types of *wattbandi* and bench terracing are considered feasible, the crucial point at which bench terracing must be insisted upon being predetermined if possible.

Results from the Uhl Survey

This Uhl experimental survey has not yet been repeated elsewhere. The publication of the above numerator and denominator system in a 1937 *Indian Forester* (pp. 218—222 of vol. LXIII) gave rise to much ribald comment, but the proof of the pudding is in the eating, and the hard facts produced by this survey have remained the basis on which the Punjab government has framed its policy. It has been a slow business, but in the subsequent 10 years we have got more or less complete control of the itinerant grazing flooks and are now demarcating the worst blocks of unterraced or badly terraced field with the object of taking them out of cultivation. The whole catchment is now accessible with a good network of inspection paths and we have built a bridle path from Baijnath *via* Bir and the Salethar Pass which puts the valley in direct touch with the outer world. The villagers whose fields are likely to be taken out of cultivation are to be offered alternative land in a neighbouring village but if sufficient emphasis is put on improving the standard of cultivation and manuring for the remaining and better terraced fields, there should be no need for wholesale migration.

The effect of closure to browsing has been quite spectacular, for the oak forest from 9,000 to 12,000 ft. has already improved enormously in the stability of humus cover and hence in the porosity of the forest floor. Unfortunately it is the land below 9,000 feet which is the crucial factor in a sustained winter flow. The higher reaches above 9,000 feet are pretty well frozen up for the 3 months of December to February and the residual flow from glaciers and permanent snow fields

remains more or less constant. The run-off from land below 9,000 feet on the other hand is subject to great vagaries during those months depending upon whether frost follows snow or snow follows frost, to govern the rate of run-off and the ratio of run-off to infiltration into the subsoil. Recent Amercian data and H. Burger's recent analysis of the Swiss Emmenthal catchment translated by Dr. A. L. Griffith,* support the contention that a much greater and steadier winter water movement can be secured from a good grass cover than from bare fallow fields. It is with the object of producing a good grass, shrub, and tree cover on as much as possible of the land below 9,000 ft. that the acquisition of badly terraced fields has been officially approved but not yet implemented. Without the convincing data produced by this erosion survey it is unlikely that government would ever have agreed to the action now being taken, as the intensity of the erosion taking place in the belt of cultivation along the lower slopes of the two valleys (55 per cent. of the 21,000 acre farm-belt between 6,000 and 9,000 feet) would never have been realised.

Provincial Erosion Survey

In those districts in which soil conservation work is well established steps have been taken to map erosion intensity on a much simpler basis so that a broad interpretation of the position can be shown on district maps and eventually on a provincial map. For this purpose 3 main groups have been located :—

(1) deeply ravined and seriously eroded,

(2) not deeply ravined but subject to serious sheet wash,

(3) wind erosion obvious.

One and two together will give us a broad indication of where counter-erosion work is most needed in the upland districts and confirmation or otherwise of our selection of areas for catchment working plans, which are already under preparation in Ambala, Hoshiarpur, Kangra, Gujrat, Jhelum, Attock and Rawalpindi. The separation of items 1 and 2 will also give us an analysis of the problem in terms of our mechanised attack, for group 1 needs heavy bull-dozers concentrated on selected points for bund building, combined with the familiar run-off control measures of closure to grazing and afforestation; while group 2 requires a more general attack in terms of widespread terracing of fields by both machine and bullock-drawn *karah* and the segregation of forestry measures to the reclamation of torrent beds and the canalisation of torrents.

For the plains it will be necessary to have a separate group 3 for appreciable wind erosion and incipient sand dunes. Major Westland Wrights' evidence at the silvicultural conference of 1945 quoting survey records of 1870 and 1935 to show desert increase is brought out by conditions on the ground.† Not only is there a general movement of sand from south-west to north-east across the plains in all the southern districts of the Punjab except where irrigation is established, but there is much local increase of sand drifts and dunes extending eastwards out of each of the main shallow drainage channels throughout the districts of Ambala, Jullundur, and Karnal and the states of Patiala and Faridkot. It is only after a fairly accurate location of such conditions that we can attempt to plan in detail our desert fringe conservation measures. Along the southern districts particularly the boundary between the tail ends of canal irrigation and the intervening patches of incipient sand dune on uncommanded land is much more elaborate than irrigation maps would lead one to expect. Between each distributary with its commanded area there lies a fringe of uncommanded land running far up in the opposite direction, so that the pattern of land use is very complicated. Unfortunately so far we have neither staff nor demonstrations established in this desert fringe and the only government holdings which we could make use of are the Agriculture Department's experimental and demonstration farms in which so far we have not been able to arrange any facilities for shelter-belt work.

In carrying out any erosion survey the following points may be of some use as a guide:—

(*a*) The technique of soil survey work can to some extent be made use of although the actual objects in view for soil survey and erosion survey are different. (G. R. Clarkes' book

*Vide *Indian Forester, Vol. LXXI*, No. 8, August 1945, pp. 285—86.
†*Vide Indian Forester, Vol.* 72, No. 2, February 1946, p. 79.

The Study of the Soil in the Field, Clarendon Press, 1936, has proved invaluable in framing the various surveys discussed above.

(*b*) A general knowledge of the region must be built up under such sub-heads as:—

Soil grouping and geology; history of settlement; types of cultivation including shifting cultivation past and present; errors in field cultivation; intensity of grazing; survival of climax forest and grassland types, if any; differences between north and south aspects.

(*c*) Soil profiles and the recognition of A, B & C horizons in undisturbed soil comparable with the relics of such horizons traceable in fields and grazing gounds.

(*d*) Observable erosion including existence of sheet wash and rills or finger gullies in both plough and grazing land; characters of soil at the plough sole; increased sheet-wash on long uniform slopes, etc.

(*e*) Evidence and deductions:—

Breaking up and dissection of water-catching surfaces; gullies active or old and healing; shape of gully bottom, whether U or V; frequency of gullies in dissected plateaux; surface stone and presence of erosion pavements of boulders or pebbles; wind-blown sand; accumulation of eroded material.

EROSION AND FLOOD CONTROL IN AUSTRIA

BY SIR HAROLD GLOVER,

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Introduction

Walking in the evening near the small village of Gusswerk in Upper Styria, I came across a tablet erected in 1879 in memory of a 16 foot flood of 1762 in the Selza river over a hundred years earlier, together with a prayer to the Virgin Mary to protect her people from such calamities in future. This set me thinking of floods in India and, more particularly, in the Punjab rivers and their tributaries in the Himalayas, where "exceptional and unprecedented" floods occur with deplorable regularity! What then has Austria done to protect her lands from floods, and are there any measures which she has adopted which would help India in its new campaign in favour of soil erosion and flood control?

The Economic Background

The people.—The hill tracts are very heavily populated. It is not possible to give data of the increase of population, which is probably considerable, judged by the numbers of children one sees in all hill villages. Every available living house is packed with refugees from Vienna and the Russian zone, while thousands of displaced persons have been accommodated in temporary camps. Occupying forces add considerably to the numbers temporarily resident in Austria but import food from outside Austria.

Before the war it was customary to export timber to Hungary and Italy, and milk, butter and cheese to the lower-lying localities in return for grain, but this is no longer possible owing to the closing of all international barriers, accentuated by the zones of the occupying forces within Austria itself. The result is, at any rate temporarily, great pressure on the land, as the farmers have been ordered to plough as much as possible in order to produce cereals to replace imported foods.

The farmers and peasants are intelligent and very industrious, they till the soil properly make the best use of the pastures and work in the forests, sawmills and paper mills. Before the war there was an outlet for the surplus population in the mines and factories, and the educated classes and technicians found work throughout central and south-eastern Europe. Industry has received a great setback owing to the defeat which Austria has sustained in war and the present outlook is not bright.

The Austrian government is looking to its forests to provide national credit and raw produce for the mills, and great pressure will be brought on the owners to fell timber for export in return for imported food and in order to provide remunerative employment for factory hands employed in paper and pulp mills.

Climatic and other factors.—In a recent number of the *Empire Forestry Journal* I gave an account of the forest and the climatic and other factors of the British zone of Austria.

Briefly, the British zone consists of the mountains and valleys of the Eastern Alps, and half of the country is covered with forest. Rain occurs at comparatively frequent intervals, and throughout the hills conditions favour the growth of trees and of grass, but are not particularly suited to arable crops.

Animal husbandry and cultivation.—Arable fields are cultivated mainly in the valleys and on the warmer slopes of the hills and cover only 12 percent of Carinthia and 14 percent of Styria. Cultivated meadows are of almost equal extent and are very highly prized, being manured and harrowed regulary.

24 percent of Carinthia and 16 per cent of Styria consist of Alpine pastures, where the cattle and a few sheep graze in the summer. The numbers are regulated so that no more cattle graze than can be admitted without harm to the pastures, the average incidence being one cow per 4 hectares, equivalent to 10 acres. Throughout the hills far greater importance is attached to meat and milk production than to wheat and corn crops, which are poor, and animal husbandry takes precedence over agriculture. Goats are not allowed in the forests.

The metal industry.—There are extensive iron ore and magnesite deposits, while lead and other metallic ores occur sporadically.

In former days vast tracts of forest were felled for charcoal for smelting the ore which was carried by men and animals to the nearest trade centres. With the advent of the railways and the import of hard coal from Czechoslovakia, Poland and the Ruhr, charcoal burning ceased and wood had a high value for use as building timber and paper pulp.

Before and during the war iron smelting and the manufacture of steel received a great impetus, but the plant and factories are mostly now out of work owing to bombing, and the taking of modern machinery by the Russians as reparations.

Sawmills and paper mills.—There are numerous sawmills driven by water power, hydroelectric machinery or by steam from wood waste, together with pulp and paper mills, some of which produce only crude ground pulp; others are of most modern design and produce every variety of finished products. In fact there is ample machinery to process far more than the annual yield of the forests.

Hydro-electric power.—Austria is very short of industrial hard coal and makes great use of its streams to develop hydro-electric power and there are many installations, both large and small scattered through the country, even the smallest villages and hamlets possessing their own plant driven by a small water turbine on the local stream.

Floods.—In the opening paragraph I referred to a memorial tablet to a flood of 1762. By the middle of the next century floods had so increased, both in violence and in frequency, as to do much damage to lands and buildings. It was recognised that the main cause of flooding was the disforestation caused by the cutting down and burning of the forests for the value of charcoal for smelting iron. At the same time its iron interests were concerned about the devastation of the forests as they had to go farther and farther afield for diminishing stocks of trees for charcoal and they asked for the forests to be preserved in the interests of the future charcoal supply.

Legislation.—In 1852 a law was passed regulating the use of the forest and insisting on all areas felled over being restocked within 5 years. The provinces controlled the administration of this law at first through the district staff (Agrarbehorde), later by appointing a technically trained forest officer (Aussichtforstmeister) as assistant to the district officer (Landeshauptmann). The forest officer is now responsible directly to the provincial forest administration, which comes directly under the chamber for agriculture and forestry (Landesbauernhammer) of the provincial government, and under the minister for agriculture and forestry in the central government.

Management of the Forests

The state and larger private estate forests are properly managed under regular working plans. These, however, allow of the clear felling of extensive areas which results in the loss of humus and soil, particularly on southern and western aspects and ridges, where already it is very thin partly owing to extensive clear fellings of over a hundred years ago, when most forests were burnt for charcoal for iron smelting.

Felling and replanting in all private estates and farmlands are subject to control by the provincial forest officers and the 1852 forest law is administered efficiently.

Cattle graze in the forests, except where rights to grazing have been bought out or commuted. In the farm woodlots grazing is heavy and the soil is hardened. Here too the removal of humus and litter seriously lowers the productivity of the soil and makes it less absorbent and retentive of water.

Management of the Farmlands

The farms consist of woods, meadows, pastures and arable fields. Wheat, oats, barley, rye, potatoes, maize, millets, vegetables and roots are cultivated, but hay and pasture are at least of equal value. The forest is used for grazing as well as for timber and, most essential, for litter, humus and moss for the stables and cowsheds. Green twigs of all species are chopped up for litter.

At the lower elevations the proportion of arable to pasture is considerable, but with increasing elevation the farmer grows less and less corn, and the farm economy is based on milk and animal products rather than on cereals.

At the highest elevations the arable fields disappear or are at the most, represented by a very few acres of rye and potatoes with a patch of vegetables.

On all slopes arable fields have been roughly terraced, the terracing going back to hundreds of years ago, its origin being lost in the mists of antiquity. Between the fields are strips of permanent grass which are manured and harrowed and mown for hay.

The meadows near the houses are all carefully manured and grass is mown. The pastures are fenced and grazed in rotation and, where not too remote from the homesteads, are manured. In fact, the grasslands receive as much attention as the arable fields.

The houses are built largely of wood, often, on ridges on the original sites which were chosen hunderds of years ago. A farm is an economic holding which on the death of an owner must pass intact to the heir, who has to pay co-laterals for their share of the inheritance. No parts of the farm may be sold to outsiders and subdivision, which has been such a curse in India and elsewhere, is not permitted.

Management of the Alpine Pastures

The farm, fields, pastures, meadows and woods have persisted intact through succeeding generations and man and his animals have lived in harmony with their surroundings—an example of true symbiosis which is to be envied by less prosperous agricultural communities!

Cattle are driven to the Alpine pastures in the summer where, theoretically their numbers are limited to those that the grass and herbage can stand without deterioration. Grazing runs are delimited by wire fences.

Actually some of the Alps are over-grazed and the upper limits of the forest are said to have receded considerably in the last two or three hundred years.

A certain amount of research into the cultivation of the alpine pastures is being undertaken: ploughing and reseeding on an experimental scale have given promising results.

Creation of a Special Stream Regulation Department (Wildbachsverbauung Verwaltung)

For many years isolated action had been taken to protect towns, villages and roads. With the advent of the railways it became more than ever necessary to prevent communications from being broken by floods, landslides and avalances and engineering works of some magnitude and great cost were undertaken.

In 1884, a special department was created with a staff of officers who had obtained their degree in forestry and had attended a special course at the high school for forestry at Vienna. This staff was responsible for special works in the catchment areas of the streams, for training streams where they debouched from the mountains and for protecting villagers by means of embankments, weirs and earthworks of considerable magnitude and cost.

The training of the rivers and larger protection works was done by the canal department (Wasserbauverwaltung) and the protection of roads and railways by means of culverts, embankments and stone and wooden breast walls by appropriate sections of the roads and railway departments.

Large sums, one million Austrian schillings, were spent annually on embankments, stream training and maintenance.

Hill sections of the streams.—The violence of the fall is reduced by horizontal wooden poles pegged down in the bed of the stream, and the banks are strengthened by wooden or stone breakwaters and retaining walls. These are needed when special protection has to be provided to land or buildings, but are supplementary to the biological control of the catchment areas.

Behaviour & control of streams on debouching from the hills.—When a stream debouches from the hills into the plains or into a flat inland valley it deposits rocks, gravel and sediment and gradually raises its own bed. A fan-shaped talus is formed and the stream tends to run along the higher ground, and in a flood it may burst its banks to form fresh channels. Where, as often happens, a village has been built on an old talus, flooding is liable to have serious consequences. Examples are Matrai and Greifenburg in Carinthia and Trieben in Styria.

The streams have been canalised and stepped with weirs at close intervals and the sides have been embanked and faced with stone masonry at great cost. The embankments are carefully and continuously kept in repair, but floods sometimes do extensive damage.

Training of streams in flat lands.—Where a stream flows through flat land it meanders and in high water overflows its banks and the land is wet and swampy. The channel is straightened and as the speed of the stream is then increased the bed is liable to scour. The banks of the streams are walled or sometimes only grassed and small weirs, generally of wooden poles are erected at intervals. Examples are numerous of which the training of the Glan river at St. Veit is most easily inspected.

Sometimes works of considerable size and difficulty have been undertaken and large rivers, for instance the Enns, have been canalised. Here also willows and alders now largely take the place of stone walls to fix the banks of the river.

Biological Control

It is regarded as axiomatic that all forests of the catchment area must be preserved in order to regulate the run-off of storm water and to prevent sudden and violent floods. The forest acts as a great sponge which soaks up the rain and prevents the rainwater from pouring uselessly down the slopes to form sudden and dangerous floods in the streams and rivers. When the layer of moss and humus is saturated, the water slowly percolates into the soil and the crevices in the rocks to emerge days or months later in springs and perennial streams. The streams regulation department undertakes works of afforestation where required, but this part of its duties is normally carried out by the local forest staff. On landslips twisted bundles of greenwillow twigs are staked and some take root, while between them various weeds, plants and seedlings of spruce and alder appear and hold the soil in place. The railway runs through sections of hill country where rocks are apt to fall and the ground is liable to slip. It has been accustomed to build retaining walls and strong timber fences, but it would appear that these are far less effective than the protection afforded by undisturbed woodlands.

There is, nowadays, a decided tendency to concentrate more on the biological control of the catchment areas rather than to rely on engineering works, which are costly both to construct and to maintain.

Overpopulation and economic pressure will tend to cause the forests to be over-felled, over-grazed and abused. Such tendencies must be resisted otherwise the economic balance will be upset, soil erosion will take place, and the rivers will come down in devastating floods to spread ruin in their train.

Austria has long recognised the need for preserving its forests, fields, meadows and alpine pastures, and has worked out a true balance between production and proper use. We can only trust that in the future as in the past use and not abuse will be the motto of the Austrain government, and that pressure by commercial interests or due to economic forces will not compel Austria to depart from a true and properly balanced and planned rural economy.

ON PYGEUM MOONEYI

By M. B. Raizada.

(*Forest Research Institute, Dehra Dun.*)

In the June issue of the *Indian Forester* for 1942, P. 421, the writer described a new species of *Pygeum*, *P. mooneyi* Raizada from Bailadila hill, Bastar state. No description of the fruits could then be given as none were available. Since then through the courtesy of Dr. H. F. Mooney, C.I.E., I.F.S., fruiting specimens have been collected. Fortunately the fruits have been gathered from the same tree from which flowering specimens for describing the tree were obtained as the tree was distinctly marked.

Since the description of fruit of *P. andersoni* Hk. f. is also not available in any of the Indian floras (Vide J. D. Hooker, *Flora of British India*, vol. II, p. 320; Prain, *Bengal Plants*, vol. I, p. 464; Brandis, *Indian Trees* p. 282; Haines, *Botany of Bihar and Orissa* p. 337; Fischer *Flora of the Presidency of Madras* vol. I p. 438) I give below the description of the fruit of *P. mooneyi* and compare it with that of *P. andersoni* as I have seen fruits of both:—

Fruit a succulent, dark purple or black, almost globose drupe about .3—.4 in. in diameter, very faintly didymous when fresh and not transversely oblong. It is smaller than and very distinct in appearance from the fruit of *P. andersoni* Hk. f. which is .5—.6 in. in diameter when fresh, transversely oblong and not didymous.

DUST—THE DESTROYER OF NATIONS

By G. W. D. Breadon

(*District Engineer, Gurdaspur, Punjab.*)

On this earth habitable land is rapidly decreasing. Already over a sixth portion of its surface has become treeless and waterless and unfit for cultivation. The desert is increasing.

In North Africa, which once constituted the *Granary of the World*, there is nothing but a vast repellent desert, which is extending southward at the alarming rate of about 35 to 40 miles a year from end to end. Persia, the great empire of the past, with Arabia, Mesopotamia, Judea and parts of Turkey and the region of the Dead Sea and Transjordan are deserts. North China is another desert and here in India we have also our deserts and more are forming. America too is in danger, for the productive top soil is being either washed away or carried off in dust. There are many more deserts on the Globe, places where human beings cannot live.

HABITABLE LAND

Man can live where the soil is fertile and where it can be kept fertile. *Soil therefore is the all-important factor.* It is the life of the people and must accordingly be carefully conserved. The conservation of soil means the conservation of water also, for both of which the reservation and preservation of vegetation as a surface cover is essential.

I have published several pamphlets: *Soil Conservation; Soil and water Conservation; Soils in Relation to Roads; The Degradation of Soil and the Cultivator*. These were widely circulated to both official and non-official persons throughout India and Burma. Also some were printed in the *Indian Forester* and in the records of the Indian road congress. Perhaps they were instrumental in the formation of the several departments now dealing with erosion and the protection of soil; or, at least, they might have contributed towards their creation. Whatever it might be, attempts are being made to restore waste land and to save others from destruction. Some good is being done, but not on a scale that is needed.

DECADENCE OF NATIONS DUE TO DECADENCE OF SOIL.

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History reveals that many nations have risen to power in this world and many have

fallen, some to almost complete obliteration. Scientific excavations and explorations are now disclosing more about ancient civilization and it does not take long to connect the decadence of the people to the decadence of the soil. Soil rot is still going on. Its rape is still in progress all over the Globe. At the outset the destruction is slow. It soon gathers momentum and rapidly passes out of the reach of man to arrest the decay.

The gravity of the situation is not correctly appreciated by nations, their governments and the press. Therefore, the danger continues and increases unhindered. There is no doubt that the subject is not understood by the masses. All may be conversant with the fact that life prospers where the soil produces food, but few know that the soil has also to be protected and fed and that water has to be conserved in the soil in order to produce food in perpetuity. The methods of soil and water conservation are not widely known.

We need the services of specialized engineers, foresters and agriculturists with the backing of a strong soil conservation department having the full support of the government, to achieve this end. A garrulous body of politicians, who are mostly short sighted and numerous, cannot guide a nation in this direction. Statesmen are needed who can see far ahead and plan for the future. *No statesman could do more lasting good for his people than to formulate a long term plan for soil and water conservation.*

Soil.—First of all let us clearly understand what soil is and how it was formed. Soil is the topmost stratum of the earth's crust or surface whence plants derive their mineral food and water. From the cultivator's point of view, it is sufficient to say that soil is disintegrated rock that has been reduced to small fragments or powder without cohesion and a good mixture of humus or decomposed vegetation which absorbs and retains moisture, and which constitutes the main cause of cohesion in the mass, termed soil. When in this mixed and moist condition, the soil stands. But when the humus is washed out of it, the binding element is removed and the remaining soil becomes dust to be carried away by wind into the sky and by water into streams and rivers and finally into the sea. There it forms silt bars and islands at the mouths of navigation channels. The danger in large countries with plenty of spare land and extensive forest areas is actually greater than in smaller countries; because the availability of fresh acres does not give much cause for anxiety when the fertility of the soil in any particular region is lost. It is a pity in one sense that the danger does not manifest itself in a quicker and a more dramatic manner; for, then people would quickly realize what is happening and take steps to avert it, or at least arrest it. Coming slowly at the start, the ignorant do not see that danger signal and when it has put on a spurt, it is too late to act.

ABUSE OF SOIL AND ITS RESULTS.

In order to form some idea of the magnitude of the menace let us take a peep into the past so far as is known to us. Let us look round the countries where wrong methods of cultivation, that is the abuse of the soil, are going on. Some people contend that war and disease have accounted for the fall of nations. These may be contributing factors which assisted and accelerated, but the main causes were bad husbandry, overgrazing and lack of soil conservation, with the inevitable result that soil turned into dust, was blown and carried away and a desert created. *Dust is the remorseless killer, the demon of destruction that shows no mercy to the improvident.*

Rome and Greece prospered and rose to great heights simply because the people knew how to make use of the soil in the proper manner to get the most out of it and yet to retain its fertility from year to year. As they grew richer and began to import more from abroad they became careless and abandoned much that they had learnt from their forefathers. The soil declined in productivity and rapidly lost its fertility. They thus resorted to war to conquer more land. In their homelands the standard of living declined and the social structure quickly disintegrated.

The Moors in their greed to conquer the southern countries of Europe quickly depleted the forests of their country for war material, overtaxed their fields in order to provide food for their armies, made the soil infertile and turned it into dust. Much of their land is now a howling desert.

The empire of Assyria and the empire of Babylon faded away not only on account

of wars but also, and mainly, on account of unscientific farming. They took all that they could get from the soil and did not put back enough to maintain it in a state of fertility. The same miserable conditions were brought about in Judea. The Philistines did not turn the country into a desert, but the people of the land turned good soil into desert. Egypt and Persia are other examples. Arabia was destroyed in like manner and North Africa, once the "Wheat bowl of Europe", is now a desert of great size and increasing southwards at an alarming rate.

North China, the cradle of a great people, where abundance of food, fodder and timber were available, is now deserted. Prolonged wars prevented the Chinese from devoting much care to the land, while all the accessible hills were denuded of their forest cover. Once exposed, the heavy rains carried away the soil. The hills and foothills were gullied, new streams created and existing rivers flooded. So great is the quantity of silt that the river is now called the Yellow River and the sea the Yellow Sea. The neglected fields became infertile and soon turned to dust.

When the Chinese moved away to fresh lands they remembered the lessons that denudation of vegetation and neglect of fields had taught them and they are today the most advanced of cultivators and the most skilful of forest and soil conservators. These good farmers are able to support a large family on one acre of land. They are most assiduous, intelligent and hardworking, but they are now up against the greatest of disasters—prolonged wars. Trees and shrubs have been cut away, canals and watercourses have become heavily silted, much cultivable land has deteriorated and everywhere can be heard the depressing cry—where are we to find the labour to undo the ravages of these bloody wars? Unless a miracle takes place one of the greatest famines of the world will sweep over China.

The United States of Amercia do not present a very rosy picture. Fortunately, however, the government and the people have seen the approaching danger brought about by soil erosion and steps are being taken to counter its effects. A lot will no doubt be done by reafforestation and contour terracing, but not enough completely to arrest the growing danger. The vast DUST BOWL is spreading and blown dust, as in North Africa, disseminates. The U. S. A. too makes the great mistake of encouraging large scale farming and the use of heavy machines with the object of producing quicker and cheaper returns and larger yields by the use of dry artificial manures. Extensive farms, worked by large machines, are not ideal methods of good husbandry; and whereas chemicals in powder form are no substitutes for humus and other organic manure, which not only supply all necessary plant food, but the mixing of which with the arable top crust makes the soil coherent and absorbent. *Unless these manures are put back into the soil a state of dryness will result and dry earth makes desert.*

Russia is aping Amercian methods of farming. She is paying no heed to soil conservation and at the same time she is heavily exploiting her timber resources, regardless of the fact that forests protect the land and also "call rain". Such apathy prevails in countries with extensive lands, but it is criminal in so far as no regard is kept for population increase or for future generations. The terrible lessons of the past make no impression and the Tundra and other wheat belts may soon become another Sahara.

In Canada, which is deplorably short of livestock, the wheat control, which encourages large wheat growers outside French Canada, and the employment of machinery on an extensive scale, the soil is being impoverished. Wheat is grown exclusively on chemicals and the top soil is crumbling. But the danger there is not so great since for several months in the year the ground is covered with snow, and in many places it freezes down to a depth of three or four feet. In this alone lies Canadas' salvation. On the other hand, the French Canadians are mostly peasants on small holdings. They practise farming on an intensive scale, keep the soil rich with organic manures and preserve a perfect tilth. In this manner no soil deterioration can possibly take place during the life of the nation.

Denmark, Holland, Luxemburg, and parts of Belgium are also the homes of small farmers, whose soils will never perish for lack of good scientific methods and sound practical husbandry.

I cannot explain why seven-eighths of Australia is a desert. A fringe round the continent

is inhabited, but the whole of central Australia is a vast expanse of sand from which dense clouds of injurious dust are blown in all directions. Extensive pastoral lands which have been overgrazed by sheep, and are subject to periodical droughts approximately every seventh year, are being forsaken as dust settles on the surface and produces infertility. In the wheat belt the soil is becoming more and more sandy and since crops are grown on chemical manures and the soil worked by heavy machines, its cohesion is disappearing and winds occasion dust storms. As cultivation advanced the fire stick is more extensively employed in the removal of trees and shrubs. The surface is exposed to erosion and the humus covering gradually disappears.

The United Kingdom soil is rich and deep, livestock is plentiful and grazing good. Grazing keeps the soil fertile by the constant addition of organic manure which the animals work into it while moving about. Rain falls abundantly throughout the year and keeps the ground moist. Very little, if any, soil erosion takes place and there is no danger of soil deterioration. Farming methods are good and holdings are, generally speaking, not large. I have not seen any overgrazing although an acre of pasture land carries more animals than in any other country visited by me. The two world wars have brought more land under the plough and under grazing. Home production of food grains and vegetable has increased, but it will never be enough to support the population. In a small and highly industrialized country much land goes under roads, buildings, aerodromes, railways and the like.

AGRICULTURAL INDIA.

Let us now turn to India, that subcontinent with a population of 400 millions of people, ninety per cent of whom dwell in villages and till the soil. India is essentially agricultural, but there are indications that it will rapidly advance industrially.

India has her deserts and her dust storms. Soil is deteriorating. The causes are many. Let us confine attention first to the Punjab. The cultivator is slow and slouchy in his movements and necessarily so because he works to the ungainly gait of his sluggish buffalo. Labouring with such dull and lazy creatures, the man not only produces less work at the expense of much wasted time and energy, but himself becomes a sluggard by association. He has not the inclination to do anything beyond the least amount of essential farm work. Perhaps for this reason he has adopted the pernicious practices of constructing heavy *watts* round his fields, irrigating excessively and shallow ploughing—practices which (even without the harmful effects in some localities of the rising water table caused by seepage from the canal system) result in *kalar*, or saltpetre rising in the soil and rendering it unfit for most forms of cultivation. I believe that from about 75,000, to 100,000 acres of land in the Punjab, are thrown out each year through *kalar* poisoning. This is a very large area to lose and steps should be taken to arrest the decay and also to reclaim lost land. It is a recognized fact that deep ploughing with turning of the soil, harrowing in order to produce a fine tilth and moderate watering will not only keep saltpetre down, but will be more beneficial to plant life since the soil will retain adequate moisture in it for the assimilation of mineral food and for the growth of vegetation.

Another evil in this country is the failure of the cultivator to give back to the soil all that he takes from the soil. The soil responds in proportion to what you put back into it in the shape of manures. Natural manures are of two kinds—humus or decayed vegetation, and dung of animals, commonly known as stable or farmyard manure. Both these are needed and when supplied in adequate quantities, the soil remains rich in productivity and good crops can be expected. But by converting dung into fuel the land is being robbed of an essential product.

SCARCITY OF FUEL AND HOW TO OVERCOME IT.

The scarcity of fuel accounts for the use of cowdung cakes. In order to overcome this shortage the provincial government should insist on the creation and maintenance of groves in every village and the formations of plantations of quick growing hardy perennial shrubs, such as *Ipomoea carnea*, known in Gurdaspur district by the name of *narel boota* and *vilaiti datura*. This all-round useful plant has been extensively used by me on river protection works, in counter-erosion schemes, or land reclamation and in place of stone and concrete facing the bank slopes on roads and canals. In the arboricultural department, I used it for

fencing young plants. Goats, camels, etc. do not eat it and insects and disease do not attack it. It is a foster mother *par excellence.* It has grown so popular that *zamindars* are now fencing their fields and gardens with it and as a fuel its demand is growing rapidly. As long as people do not cut out the roots the plant survives heavy annual cutting. It is propagated easily by cuttings and will grow almost anywhere in the plains. On the Bein river protection works in the Shakargarh *tehsil*, Gurdaspur district, the inhabitants of four villages derive all the fuel they need from the plantations along the bunds.

In this *tehsil*, which remained the Cinderella of the district until I opened up roads connecting it with Sialkot, Gurdaspur, and Dera Baba Nanak, which placed it in a somewhat more favourable position, some of the most striking examples of soil erosion in all its forms, can be seen. All along the north, bordering the Jammu state, the land is a shambles—a veritable slaughterhouse with the top soil gone and gullies and ravines everywhere. The anti-erosion branch of the forest department has undertaken some protection and reclamation work, but it is on a scale too small to do any good. The *wattbundi* scheme, which is being advocated in villages where it was never before used, is useless, since the soil, described locally as "hard as iron in the heat, but soft as cowdung in the wet" does not stand in the *watts*, and fortunately so, since *wattbundi* is a noxious practice except in the case of rice fields and allied wet cultivation.

CONTOUR TERRACING FOR SOIL CONSERVATION AND RECLAMATION

Some years ago, near Shakargarh and at the village of Fathu Chak, about four miles, away on the road to Ikhlaspur, I demonstrated the American methods of contour terracing, gully plugging and drainage in relation to soil and water conservation, on two large areas, I induced the *zamindars* to cultivate on the land advising them to maintain the levels in good condition and to take care of the drains. All went well for two years and good results were obtained, but unfortunately the forest ranger of the anti-erosion department stepped in and destroyed both the demonstration plots by introducing the *wattbundi* system, which in most cases, overlapped the contour terracing and completely obliterated the levels and the drains. On the Shakagarh plot the *zamindars*, to a great extent, stopped cultivating and in the place of wheat, *makki* and the like, young *Kikar* (*Acacia arabica*) came to life and now there is a fairly good *kikar* forest. At Fathu Chak, nine-tenths of the *wattbundi* area is again fallow. Much of the soil was ruined when table terracing was resorted to. The earth from the higher parts was cut and spread over the lower portions resulting in the whole of the surface soil being buried under subsoil of no productive value. I had warned the officers and subordinates of the wrong they were doing, but the work went on.

The term "contour terracing" as understood and practised in America, is not understood in India, where "terracing" is taken to mean "table terracing" *i. e.* the laying out of sloping land in a series of level fields in tiers one above the other, such as we see in the hills. "Contour terracing" too does not clearly express the layout of the *bunds* with their component catch-water drains, but in the absence of a more appropriate term, we should not change it. The slope or grade of the land determines the distance between the ridges laid out by the surveyor. He lays out the catch-water drain and ridge giving it a gentle side slope in the direction of the gully into which unabsorbed surplus water will be discharged. The drain thus gradually leaves the contour line, but still is not too far away from it. The earth from the drain is heaped up along the drain in *bund* form on the lower side of the slope. For fuller particulars I would refer the reader to my pamphlet *Soil Conservation*, a few copies of which are still with me and could be supplied on application to those who are interested.

A WARNING AGAINST ADOPTING RUSSIAN AGRICULTURAL METHODS

I have listened in to the wireless and also read in the papers that the Punjab government looks favourably upon Russian Communism and Russian methods of agriculture. I refrain from commenting on politicial subjects, but I do think that I should strike a note of warning against the Russian agricultural methods. India cannot afford to copy the American as Russia is doing. State farming and large community farming with

heavy machines on extensive areas with artificial manures are pernicious. They convert arable land into dust and dust soon drives the cultivators off the land to fresh land which they can till. *The method is criminal since it destroys land, converting it into a desert. It devestates a heritage and pays no regard to future generations.*

THE CALL FOR HIGHER STANDARD OF LIVING.

From every country in the world we hear the call for a higher standard of living and governments have to pay heed to this cry. Scientists are working in all directions for better methods of production. Hygiene, for the prevention of disease and the preservation of health is advancing and spreading. Sanitation is being improved. Hospitals are being built and water supply is receiving attention. Various welfare societies have been established—all for the benefit of mankind and aiming at the increase of population. Man and the animals he needs, live on the products of the earth—mainly food which comes from the soil. Soil is being destroyed to an alarming degree everywhere. Deserts are being created and dust is spreading disaster. *What will happen when the population of India increases and there is not enough land to sustain it? Famine and death, or a war of aggression to grab the lands of other nations which are more fortunate. The old, old story to be repeated again.*

Let the politicians be guided by statesmen in the matter of agriculture if not in any other direction, for on agriculture India can live and prosper. A long term policy is needed and very careful planning. Indian methods of farming can be greatly improved, but the small farmer should not be displaced. The estates should be broken up and government should control production, collection and distribution of food to prevent hoarding, cornering and exploitation, which so often cause distress and even famine. The status of the ciltivator should be raised from the state of degradation to which he has been reduced.

THE ATOM BOMB LESS HARMFUL THAN DUST.

The world now knows a great deal about the atom bomb, but in dust there is a far greater destroyer and one that works with greater certainty and on a far wider scale. Dust has destroyed nations and dust is still the destroyer of nations.

Note on the Above by the Soil Conservation Circle Punjab.

Under 'Agricultural India' the author leaves an impression that buffalo is the chief animal used by the ciltivator for field work in the Punjab. The buffalo is only used for ploughing in a few of the Punjab rice areas. Elsewhere the bullock is used universally. Under the same heading the author is confusing 'irrigated' with 'rain-fed (*barani*)' land. There is no question of waterlogging or *kalar* poisoning in *barani* land where good *wattbundi* is the only possible way of catching enough moisture to raise a wheat crop. Further on he advocates 'moderate watering'. Heavy watering resulting in the washing away of salts, removes their toxic effects and as such is more beneficial than shallow watering in *kalar* soils.

Under 'scarcity of fuel' the author advises the formation of plantations of *Ipomea carnea* to meet fuel demands of the Punjab. *Ipomea carnea* is useless as fuel though excellent for soil conservation works. It can grow only in areas registering over 35 inches rainfall. *Ipomea carnea* is not in demand as fuel but is used by poor people in times of scarcity. Unfortunately the species gives very disappointing results in the western and drier parts of the Punjab as it is much less prolific there. The author deprecates the practice of *wattbundi* of fields by *zamindars* as advocated by the soil conservation officers of the forest department, and alleges it to be useless. *Watt bundi* is universally successful in the sandy loams of the rest of the Punjab; but apparently some modification of the principle of contour ridging is required in the hard clays mentioned by the author. Where *watts* do not stand a heavy downpour and have to be repaired frequently, there even they are very popular with the *zamidars,* since they have been responsible for increasing the yield of crops appreciably.

Under 'contour terracing' he alleges that the soil was ruined when table terracing was resorted to. That is not correct. Terracing

has yielded excellent results by preventing the top layer of fertile soil from getting washed away and is very popular. It is not being practised on a large scale due to its being an expensive operation. One can hardly agree with his observation regarding the failure of India correctly to understand and practise "contour terracing" in the Amercian way. The observation, we are afraid, is entirely wrong.

EXTRACTS

TREES AND THEIR HABITAT

M. S. Randhawa

(*Secretary, Imperial Council of Agricultural Research.*)

Bioaesthetic planting of ornamental trees has a close relation with plant ecology. Study of ecology is essential for the bioaesthetic planner. He must place plants in habitats which approximate to their natural surroundings. The texture of soil, amount of rainfall, presence of rivers, canals and tanks, and temperature play an important role in the growth of trees. There are certain trees which flourish only in moist districts with a rainfall of over 40 in., or along the banks of rivers, canals and tanks. In districts with less rainfall, these trees can grow if artificial means of irrigation are available, but they never acquire the same stature as in moist areas. This does not mean that such trees should not be grown at all in dry areas. If means of irrigation are available these may be grown. A dwarfing in size takes place when trees which are inhabitants of moist districts are grown in dry areas, and this is an advantage when considered from the point of view of the owner of a small compound. *Lagerstroemia flos-reginac* which is a big tree in Bengal, is a medium-sized tree in the Punjab and the United Provinces. The trees which are suited for moist localities are shown in Table. I.

A careful scrutiny of Tables I and II shows that out of 20 trees we have selected for moist areas, there are 12 which are natives of foreign tropical countries with heavy rainfall and high humidity.

On the other hand out of the list (Table II) of selected ornamental flowering trees, there are 14 trees which can stand drought and shortage of water. These are trees with special structural modifications which enable them to cope with dry conditions, heat and shortage of water. Some of them have long roots and waxed leaves which check evaporation of water. Out of these there are 10 trees which are indigenous and thus ideally suited for dry tracts of our country. These trees with xerophytic features can flourish in dry areas where irrigation facilities are poor and hot dry winds check the growth of trees. These trees can tolerate arid conditions, but this does not mean that they love drought and heat. They can grow in moist districts as well and do very well indeed.

Moisture-loving trees

However, when we have to plant the banks of a canal, a river or a tank, we should select moisture-loving trees only, such as *Lagerstroemia flos-reginae*, *Salix tetrasperma* (willow), and *Sapium sebiferum* (*makhan*). The last one which is also known as the Chinese Tallow Tree is a medium-sized deciduous tree whose leaves display lovely autumn tints and is used for stream training in Kangra and Jhelum districts.

There are very few trees which can grow in marshy waterlogged areas. *Eucalyptus rostrata* has proved a success in waterlogged areas near the Upper Jhelum canal in the Punjab. Willows and *Tamarix* are also suitable for such areas. Where adequate protection against animals is available bananas may also be tried. These trees can also be used for draining puddles

which form near wells in our villages. It is suggested that these puddles should be enclosed with brick-walls to protect the young trees from cattle, and planted with the trees mentioned above. Where the soakage pits have failed to drain, these trees might succeed.

Soil

Soil plays a very important role in the life of trees. High, well-drained soil of mixed sand and clay is ideal for the growth of trees. Waterlogged, low-lying areas produce stunted growth. There are certain trees which can flourish in poor sandy soil. These are mostly members of the family Leguminosae whose roots harbour nitrifying bacteria in tubercles which fix atmospheric nitrogen and make it available to the tree. Then there are trees which can cope with alkaline soil, such as *Butea frondosa*, the common *Dhak*. In fact trees serve as a valuable index of the type of soil on which they grow. Further there are trees which can grow on dry rocky areas with minimum of soil, such as *Cochlospermum gossypium*, *Cassia fistula*, *Prosopis juliflora* and *Plumerias*. These trees are ideally suited for covering arid hills such as those found in Central India and Rajputana.

Animals, particularly goats, are the chief enemies of young trees. Some trees like *Cassia fistula* contain chemicals in their sap, and that is why goats, cows and buffaloes will not touch the leaves of *Amaltas*, which have a purgative action on their digestive organs. Hence *Amaltas* is well-suited for planting waste-land which cannot be protected from grazing animals.

Tropical trees and frost line

Frost Line may be described as an imaginary line which passes through districts below which frosts never occur. Roughly this line extends from the sub-Himalayan districts of the United Provinces to the eastern districts of the Punjab. From our point of view the significance of this line lies in the fact that majority of the denizens of the equatorial and monsoon forests are unable to flourish in areas above this line. Given sufficient protection in winter they may grow in the area above this line, but these trees are quite *unable to reproduce themselves* in areas where frost occurs. This explains why *Colvillea racemosa* produces so few seeds even in the United Provinces. Out of trees we have listed as suitable for moist localities, there are 12 trees which are natives of tropical countries like Africa, Madagascar, Java, West Indies, Malaya and Burma. These trees cannot be satisfactorily grown in the Punjab, North-West Frontier Province, Kashmir and the Himalayan zone. In this matter the United Provinces of Agra and Oudh, Bihar, Bengal, Madras, and Bombay provinces are more fortunate and the choice of trees available for planting is larger as compared with the northern area above the frost line. In these areas only indigenous trees which are adapted to our climate are indicated, and it would be futile to grow Pink Cassia, Colvilleas and *gul mohurs* at Lahore and Peshawar.

TABLE I

List of ornamental flowering trees suited for moist localities

Name of Tree	Country of origin	Time of flowering	Colour of flowers
1. *Amberstia nobilis*	Burma	March	Golden-yellow
2. *Bauhinia variegata*	India	March-April	White, pink or mauve
3. *B. Purpurea*	West Indies	February-March	Scarlet-red
4. *Brownea coccinea*	do.	do.	do.
5. *B. ariza*	do.	do.	Rose-pink
6. *Cassia marginata*	Ceylon	May-June, and October	Terra-cotta red
7. *C. javanica*	Java	do.	Rose-pink
8. *C. nodosa*	Eastern Bengal and Malaya	do.	Bright-pink
9. *Coluillea racemosa*	Madagascar	October-November	Scarlet-orange
10. *Guaiacum officinale*	West Indies	March-April	Blue
11. *Lagerstroemia flos-reginae*	Bengal	April-May and July-September	Mauve-purple
12. *L. Thorelli*	India	do.	White-mauve
13. *Milletia auriculata*	Burma	March	Purple-mauve
14. *Poinciana regia*	Madagascar	April-June	Scarlet-orange
15. *Peltophorum ferrugineum*	Malaya	October	Golden-yellow
16. *Pith clobium saman*	Brazil	March and September	Pale-pink
17. *Sar a a indica*	India	February-March	Scarlet-orange
18. *Solanum wrightii*	Brazil	All the year round; particularly in October	White, and Purple-blue
19. *Spathodea campanulata*	Tropical Africa	February-March	Orange-red
20. *Sterculia colorata*	South India	April-May	Orange-red

TABLE II

Ornamental flowering trees suited for dry localities

	Name of Tree	Country of origin	Time of flowering	Colour of flowers
1.	*Acacia auriculiformis*	Australia	October-November	Yellow
2.	*Butea frondosa*	India	March	Orange
3.	*Cassia fistula*	India	April-May	Yellow
4.	*Cordia sebestena*	South India	All the year round particularly January to March	Scarlet-orange
5.	*Cochlospermum gossypium*	do.	March	Yellow
6.	*Erythrina indica*	India	February-March	Scarlet-red
7.	*E. Blackeii*	India	April	Cinnamon-red
8.	*Jacaranda mimosaefolia*	Brazil	March-April	Violet-blue
9.	*Melia azedarach*	Punjab (India)	April	Lilac
10.	*Plumeria alba*	South America	March-Aprlil July-October	White
11.	*Pongamia glabra*	India	May	Mauve
12.	*Spathodea nilotica*	Tropical Africa	February-March	Orange-crimson
13.	*Tecomella undulata*	North India	March-April	Orange-yellow
14.	*Thespesia populnea*	India	All the year round; particularly in October and November	Yellow and Reddish-purple

TABLE III

List of drought-resistant trees suitable for arid regions

Albizzia lebbek	*Siris.* A deciduous, spreading, fast-growing tree, 40 to 60 ft. high. Thrives in the Punjab, Rajputana and South Persia. Moderately drought-resistant.
Butea frondosa	*Dhak* or *Pulas.* A medium-sized deciduous tree, gets covered in March with scarlet flowers. Extremely resistant to drought.
Cassia fistula	*Amaltas.* A medium-sized deciduous tree, 30 to 40 ft. high. Gets covered with golden-yellow flowers in May.
Casuarina equisetifolia	*Beef-wood Tree.* A tall evergreen tree; 50 to 60 ft. high; with long needle-like leaves; native of Australia, grows well on dry sandy soil. Thrives in the Punjab.
Eucalyptus citriodora	*Safeda.* A tall evergreen tree: thrives in the Punjab and Iraq.
Melia azedarach	Persian Lilac, *Dake*, *Bakain*. Deciduous tree, 20 to 40 ft. high. Purple panicles in March. Flourishes in the Punjab.
Morus indica	Mulberry, *Toot*, Thrives in the Punjab, Syria and South Parsia.
Phoenix dactylifera	Date-palm, *Khajoor*. Flourishes in Western Punjab, Persia and Iraq.
Prosopis Juliflora	Mesquit Bean. A deciduous tree, medium sized, graceful feathery foliage. Of quick growth, extremely drought-resistant, a native of Mexico.
Salvadora persica	*Pilu*, Mustard Tree of Scripture. A small evergreen tree with small oval-fleshy leaves. Extremely drought-resistant, flourishes in Western Punjab and Persia.

TABLE IV

List of salt-resistant trees

Butea frondosa	*Dhak*, ***Pulas***. Extremely salt-resistant, in fact, the only tree which grows successfully on saline, ***usar*** and *kalar* soil.
Bassia latifolia	*Mahua.* Moderately salt-resistant, can grow on slightly saline soil. Yields good timber and edible fruit which can be fermented into liquor.
Eucalyptus citriodora	Moderately salt-resistant. Grows even in Iraq.
Azadirachta indica	*Neem.* Moderately salt-resistant.
Phoenix dactylifera	Date-palm, *Khajoor*. Flourishes in brackish soil.
Phyllanthus emblica	*Amla.* Flourishes in slightly saline soil.
Psidium guava	Guava. Can easily grow in mild *usar*.
Tamarix articulata	*Farash.* Thrives in arid saline soil.

TABLE V

List of trees for swamps and marshy areas

Eucalyptus rostrata	Has a high rate of transpiration and is useful for draining marshy areas.
Salix tetrasperma	Willow. Ideal tree for water-side planting.
S. babylonica	do.
***Tamarix* sp.**	*Farash.* Can stand waterlogging.
Plantains	***Kela.*** **Its broad leaves have a high rate of transpiration.**

TABLE VI

Nectar-yielding trees

1. *Bauhinia purpurea*
2. Bottle brush (*Callistemon lanceolatum*)
3. Horse Chestnut (*Aesculus indica*)
4. *Jaman* (*Eugenia jambolana*)
5. *Kachnar* (*Bauhinia variegata*)
6. *Neem* (*Azadirachta Indica*)
7. *Sheeshum* (*Dalbergia sissoo*)
8. Soapnut (*Sapindus*)
9. *Tun* (*Cedrela toona*)
10. *Barna* (*Crataeva religiosa*)

TABLE VII

Fodder trees

Toot (*Morus alba*)
Kachnar (*Bauhinia variegata*)
Peepal (*Ficus religiosa*)
Neem (*Azadirachta indica*)
Babul (*Acacia arabica*)
Haldu (*Adina cordifolia*)

—*Indian Farming*, Vol. VII, No. 5, May, 1946.

WHERE DO OUR FORESTRY SCHOOLS FAIL

Eleven foresters, members of the forestry seminar class at Biarritz American University, present a searching and constructive analysis of some of the weaknesses in current instruction at schools of forestry in the United States.

At Biarritz American University, Biarritz, France, this important question was discussed at length by 11 graduate foresters. Our group represents a cross-section of American forestry schools, and we have a wide range of experience in both federal and private forestry. As veterans with a few months to several years of overseas experience, we have the advantage of perspective. We have compared the requirements and status of forestry education in the United States with that in Europe, only to find that our own education has not been adequate. We believe that we have a responsibility to our profession to suggest in a constructively critical manner some ways in which, in our opinion, our own forestry schools may be improved.

Briefly, we find the following weaknesses to be most apparent in the forestry training now given in our schools:

1. Lack of a sufficiently broad educational background in the forestry curricula.

2. Too much poor instruction and too many poor instruction methods.

3. Insufficient attempts to obtain the highest calibre students in the forestry field and insufficient weeding out of misfits.

4. Poor student counselling service.

5. Inadequate development and utilization of on-the-job training programs.

6. Limited use of field trips.

7. Overemphasis on civil-service examinations.

Individual weaknesses are more apparent in some schools than in others, but as a whole our entire system of forestry education needs to be seriously analyzed and improved.

Recognition of the educational institutions' many complex problems is due. They include those of finances, of meeting state policies, and of working with inadequate personnel, school plant, and facilities. Notwithstanding, improvements can be made.

[1]A statement by the forestry seminar class, Biarritz American University, France.

A well-rounded education may properly be considered the first requisite of a professional career in forestry. As forestry graduates we feel that the present forestry curricula do not provide a sufficiently broad background on which to build a career.

Now from a practical standpoint, what does a forester need in order to give him this broad background? In addition to the fundamental sciences, he should have a good grounding in liberal arts courses, among which economic geography, history, foreign languages, and psychology might be mentioned as but a few of many possible choices. In building this broad background, few prescribed courses should be required. The student, assisted by good counselling, should be given freedom in choice of electives. The schools should provide a wide range of desirable choices in liberal arts, and should help the student to develop in keeping with his aptitudes and interests. Since administrative work is an important part of every forestry activity, the forester should have a good knowledge of business administration, business law, accounting economics, leadership, and personnel management. These may well be combined into one or more courses specifically adapted to the forester's needs. Lastly, every forester should have a thorough grouuding in business English, technical report writing, and public speaking, in which most graduates are woefully lacking. The recommendation of these courses points to the need of a five-year program, which has already been adopted by some schools.

In the field of forestry itself there is also much room for progress. Methods of instruction have fallen far behind the times in many cases. In at least one school discussed, the mensuration instruments in use were excellent museum pieces. Quite often the presentation of new developments and methods has been similarly neglected. In streamlining and improving instruction, the use of films and visual aids should be stressed. Facts thus presented are easier for the student both to grasp and to remember. Better correlation of classroom work with practical application in the field is another very important rule of good instruction.

A study of the bulletins of many schools reveals that some instructors attempt to teach too many courses and at the same time cover too many distantly related fields. It is high time to admit that no man can be an expert in every field of forestry endeavor. In this connection, no school should attempt to offer a complete forestry curriculum with a staff of only three or four professors.

Another incongruous idea is for a forestry school to offer a minor in a field of little or no importance in its region. Logging and range management are cited as examples. Particularly in the eastern half of the United States, these courses might easily be tied in with farm forestry. Increased use of combined courses for subjects of less value and importance should be investigated. Forest history, forest products, timber physics, wood technology, and some other courses might well be streamlined. The subject matter of each course should be carefully reviewed and useless material culled.

Furthermore, the deans of the forestry schools should become better acquainted with the subject matter and value of the courses their students study in other colleges on the campus. As a case in point, one man in our group took a course in public speaking and did not have a chance to give a speech all term. Most of us have taken courses in English composition, which could have been much improved and better fitted to our requirements. These and other instances point to the fact that many subjects outside the forestry college must either be improved or special courses offered which are adapted to the forester's specific needs. The deans of the forestry schools are directly responsible for plugging these loopholes in forestry education.

A treatise could well be written concerning American forestry instructors. Many have masters' and doctors' degrees but have had very little, if any, field training in the subjects in which they instruct. A prerequisite for new instructors should be at least several years' experience in their own fields. Such a prerequisite would have the added advantage of eliminating many instructors who teach for a salary and not because teaching is their chosen vocation. Practical field experience should not cease once the instructor has secured the position. Instead, a regular period of field training should be incorporated into the school plan, possibly in conjunction with on-the-job training of students. Instructors who have been teaching many years and have difficulty in keeping up with new trends

in the field should be retired to make way for younger men. Deans and older professors should make greater attempts to encourage these younger instructors rather than to dominate them, as is done in all too many cases. A system of yearly efficiency ratings such as is used by most government services could possibly be applied, with a raise in salary for those instructors who consistently receive high ratings. Special inducements should be offered in order to secure and hold good field men, as many of our best instructors revert to other fields for financial reasons.

The question of weeding out misfits is always timely. In Europe, where most forestry schools are state-controlled, only a limited number of students are permitted to study forestry. One year of employment in the field before entering the school is compulsory in most European schools. We can accomplish the same end by skilfully guiding men who are obviously not suited to forestry into other studies. A constant weeding process must be used throughout the entire college course. Too much emphasis is put on grades and on simple memory or polly-parrot tests, with no weight on constructive thinking or expression. Three summers of on-the-job training, discussed later, should eliminate those who enter the field largely because of romantic ideas with no realization of the true nature of the work. Before graduation, a comprehensive written and oral examination should be given to determine what the student has actually learned and what correlation he has attained between the various subjects. In addition, consideration should be given to the individual's adaptability to field work and his ability to meet the public and to grasp the everyday problems of the forestry profession. The forestry degree should be awarded only on the results of these examinations. Through this method the schools could justly emphasize the quality rather than the quantity of graduates.

Of primary importance is a thorough and sincere counselling service. Fresh men, who know only that forestry in general holds an appeal for them, should have courses suggested which best meet their capabilities and aptitudes. Counselling becomes increasingly important in the following years when decisions must be made in selecting the branch of forestry to be followed. Improved instructor-student relationships through smaller classes go hand in hand with a good counselling program.

The forestry schools should exploit to the greatest extent on-the-job training programs through summer employment in different branches of forestry. This requires active co-operation with federal, state, and private agencies. Training not only affords the student an opportunity to absorb a wealth of practical experience unobtainable in the classrooms, but also gives him the practical adaptation of technical material. The same program could be employed in securing positions for graduates.

All too often the forestry student obtains little benefit from a course due to lack of understanding of the practical value of the subject matter. Better use can be made of field trips, some of which should take the student into other regions. The forester's laboratory is the out-of-doors. Let's utilize this excellent laboratory to the utmost! More field trips specifically related to classroom work would increase the forester's confidence in his technical ability as well as broaden his perspective. Far too many forestry schools place overemphasis on civil-service examination. A large part of their educational program is aimed only at producing a graduate who can pass the J.F. examination. The value of such a policy should be honestly and sincerely questioned, particularly in view of the fact that an increasing percentage of foresters depend less and less on government employment.

This statement is not a broadside at all schools. Many have made marked progress toward the elimination of some or all of the weaknesses discussed here. It is our sincere wish to give full credit for progress already made. However, we would still urge all the schools to re-examine curricula, faculty, and policies for possible further improvement of forestry education.

Now is the time for us to realize that forestry, while not actually leaving the woods, is entering more and more into the public life of the community. Here in Europe our profession capably holds a position of far greater responsibility in public affairs than it does at home. The American forester must also take his rightful place in society along with other professional men. Our forestry

schools must constantly strive to improve their educational programs to fill the needs of the forester in the world he faces today.

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ROYCE O. CORNELIUS, B.S.F., 1941, University of Washington.

HENRY EASTMAN, B.S., 1936, University of New Hampshire.

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ADRIAN GILBERT, B.S.F., 1943, University of Michigan.

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HEBER D. LESSIG, B.S., 1938, Pennsylvania State College.

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MELVIN P. TWERDAL, B.S., 1935, M.F., 1936, University of Washington.

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—*Journal of Forestry*, Vol. 44, No. 3, March 1946.

THE PROBLEM OF KANS

There are many factors which affect agricultural production adversely and are thus in direct conflict with the interests of the farmer. One of these is the infestation of arable lands with weeds. Weeds cause damage to the crops sown in various ways and thus bring about a poor return to the farmer. Weeds exhaust the soil of its nutritive components and moisture, which would otherwise sustain cultivated plants and thus effect a considerable reduction in yield and quality; in extreme cases of heavy infestation cropping ceases to be an economic proposition.

Kans grass (*Saccharum spontaneum*) is one of the most pernicious weeds in this country. This weed is widely distributed in all parts of India, specially in the plains, and particularly in the Central Provinces, Malwa plateau and in the Terai Zone of the United Provinces. The degree of infestation may be judged from the fact that in extreme cases, there is no other alternative left but to give up cultivation of the particular land. Howard and Howard[1], aptly sum up the situation thus: 'At the moment over a larger portion of the chief cotton tract of India, *kans* is king and the cultivator is his subject'. The monetary loss for which this particular weed is responsible has not been computed but 'at a conservative estimate the reduction in the yield of cotton caused by this weed is at least a third of the crop[2]'.

Kans belongs to the large family of grasses, and, as the botanical name implies, is allied to sugarcane. It has erect, tall and thick shoots and grows into a dense bushy cover on the land it infests. The underground stems, technically known as rhizomes, and roots are deeply laid inside the soil about eight or nine inches below the surface and form a sort of underground network holding the soil securely in the meshes. The plant multiplies mainly by means of its rhizomes, which also serve as a storehouse of food materials for the plant, but propagation by seed probably also plays an effective part. The rhizomes are useful organs which, in addition to the reproductive functions, are particularly helpful when the parts above the ground are exposed to unfavourable conditions.

Both rich and poor types of soil lend themselves to the growth of the weed but, as is to be expected, growth is more luxuriant and infestation particularly heavy on rich soil.

As to the mode of its first appearance on fields, previously uninfested, nothing seems to be definitely known. It is quite probable that the seeds of the crops to be sown are contaminated with the seeds of *kans*. And

[1]Howard, A. and Howard G. L. C. (1929). *The application of Science to crop-production*, Cambridge University Press.

[2]Howard, A. (1927). *Agricultural Journal of India*, 12,39.

therefore at the time of sowing, *kans* seeds, together with those of the crops, are introduced unawares into the field. Or, when a plot of land is left altogether unattended, the seeds may be carried to it by wind and rain. The most favourable period of growth seems to be during the monsoon months. The chief effects on the soil are that the weed exhausts the soil of most of its nitrogen content and sucks up water even from the deeper layers with the help of its penetrating root system. Because of the progressive depletion of soil nutrients, it is no wonder that *kans* dies off by itself if the land is allowed to lie fallow for a prolonged period[3].

From what has been said above it is apparent that in order to counteract one of the major factors diminishing agricultural production, this weed must be controlled or, preferably, eradicated. Various methods have been proposed from time to time for dealing with this weed; these may be grouped under three heads: (1) mechanical, (2) biological and (3) chemical. It will be profitable to examine the methods proposed separately.

The mechanical methods may be taken up first for consideration. Ploughing is one of the methods advocated and, to a certain extent, success seems to have been achieved. The underlying idea appears to be that by ploughing, the underground parts of the weed, *i.e.* rhizomes, would become detached, exposed and would ultimately be desiccated and killed by the sun. Since the plant has rhizomes and roots well below the surface soil, ploughing has to be necessarily deep enough to effect their exposure. The use of tractors for this purpose, although highly desirable, is precluded because of the expenditure involved. 'An adjustable *bakhar*' according to Howard[4] capable of working to the depth of 8 to 9 inches 'can be usefully employed for this purpose'. 'The broad share of this plough, when the wings and sole are removed, acts as a very efficient and self-clearing *bakhar* blade and uproots the dense mass of *kans* rhizomes'. Ploughing and cross-ploughing are recommended in the beginning of and during the rainy season or towards the approach of winter which synchronizes with active growth-period of the weed. Even after these operations, pieces of rhizomes, which remain alive, may put forth fresh shoots; these have to be dug and destroyed. This method has the advantage that the 'soil is lifted, not inverted, and no interference with levels takes place'. The cost of the implements required is not prohibitive and a *kans*-infested field can be reclaimed within a year.

It has, however, been pointed out that the method detailed by Howard serves at best only to control the weed and not necessarily to eradicate it. The isolated shoots, appearing after the completion of ploughing operations, have to be attended to and this adds to the total cost of eradication. Further, pieces of rhizome escaping injury and desiccation are potential sources of re-infestation.

The Department of Agriculture of the Central Provinces and Berar[5] recommends the adoption of the 'cultivated fallow system' for the eradication of the *kans* weed. The land is ploughed several times a year but no crops are grown. The implement used is a *desi* plough. By continuous ploughing and cross-ploughing the grip of roots on the soil is relaxed; the underground parts are also exposed thereby. It has been suggested that eradication is effected by this method to an appreciable extent in about a year's time. The use of *desi* plough, as proposed in this method, is no doubt an attractive feature from the point of view of ordinary farmer who can ill-afford costlier implements. But leaving the land fallow for the whole year prevents the farmer from getting any returns from it and ultimately adds to the expenditure incurred in the eradication of the weed. Moreover, scattered bits of rhizome escaping injury and remaining unattended to for a long time may lead to resumed growth and possible re-infestation.

Another method has been tried at the Izatnagar Farm of the Imperial Veterinary Research Institute and has been reported by Hosain[6]. The method essentially consists of cultivating the land with a 'Victory' plough, and at the same time, picking out the exposed underground parts from the furrows. The operations are carried out after the *rabi* crop has been harvested and, previous to ploughing,

[3] Prasad, A. (1912). *Agricultural Journal of India*, 1.208.

[4] Howard, A (1927). *Agricultural Journal of India*, 12, 39.

[5] *Eradication of kans by the cultivated fallow system.* Leaflet No. 16 of 1937, Department of Agriculture, C. P. and Berar.

[6] Hosain, M. F. (1944). *Indian Farming*, 5, 128.

the land is softened by irrigation. Sunn hemp is then cultivated; after the plants have attained a certain height, they are cut down and allowed to decompose on the field. This prevents any fresh growth of isolated rhizomes. This method is somewhat different from the foregoing ones in that it makes use of biological means of control together with purely mechanical devices.

All the mechanical methods described above suffer from obvious defects either in the shape of special implements or employment of extra labour, thus increasing considerably the cost involved. Further, it is doubtful whether by mere exposure the underground parts are completely killed. On the other hand it appears conceivable that some isolated portions may retain the capacity of initiating fresh growth and these may possibly help in the re-infestation of the treated land afresh.

With regard to the biological control methods it has been held that these are more effective and that eradication is more complete. Tambe and Wad[7] suggested that the weed could be exterminated simply by providing adequate cover to the land infested by it. They found that *Crotalaria juncea* (sunn hemp) could be successfully employed for this purpose. The plants are grown to a certain height; they are then cut down together with the weed, spread over as a sort of cover on the land infested and allowed to decay there. Any other material could be used as a cover; *bhoosa*, for example, or even a collection of the weed itself could be used for this purpose. A heavy layer of manure would serve as well or bunding the land and filling it with water, [8, 9] but in the case of such treatments the cost would be prohibitive.

The method outlined above, besides being simple, has several additional points in its favour. It does not require any special appliances and involves no extraordinary expenditure or unusual employment of labour. It has the additional advantages that the time required is rather short, that the land is enriched by the decomposed covering matter and that more or less complete eradication can be effected.

The control of the weed by means of chemical substances remains to be considered. A variety of chemicals have been employed for weed killing or weed eradication in foreign countries. These have been used in various ways. For example the soil may be rendered unsuitable for particular types of weed by altering its acidity by the application of certain chemicals. In other cases the weed may be scorched by the chemicals employed or be killed as a result of the toxic or poisonous effects induced by these.

Very little work seems to have been done in India on the control or eradication of weeds by chemical substances. Tambe and Wad[10] write that 'chemicals such as sodium chlorate, sodium arsenite and sulphuric acid have recently been employed for weed eradication but trials with these chemicals on *kans* have not given satisfactory results and their application was laborious and costly'.

From the above brief review it would be clear that the various methods employed for the eradication of *kans* have been tried far too exclusively of each other. It has not been generally realized that the results obtained from one method may be helpful or even complimentary to those from another. Thus a combination of several methods may prove more fruitful than the employment of any one singly. The results obtained at the Izatnagar Farm encourages such a belief.

Plant hormones have recently been successfully used for killing weeds[11]. A number of chemical equivalents of actual hormones have been discovered which, while adversely affecting the development of weeds, leave many cultivated crops unaffected. One such compound, named Methozone (4-Chloro-2-methylphenoxyacetic acid), has been found to be amazingly successful in killing weeds. It has been observed that it would kill various weeds without causing any damage to the cereal crop grown when applied, either in solution or as powder, at the rate of eight ounces per acre. The discovery that hormone preparations may be used for fighting weeds opens up fresh avenues for attacking a baffling enemy. How far the application of this discovery may be helpful in this country remains to be seen.

—*Indian Farming*, Vol. VII No. 4, April 1946.

[7] Tambe, G. C. and Wad, Y. D. (1938). *Agriculture and Livestock in India*, **8**, 597

[8] *Eradication of kans by the cultivated fallow system.* Leaflet No. **16** of 1937, Department of Agriculture, C.P. and Berar

[9] *The eradication of kans, kanda, Dub and Nagarmotha* Leaflet No. **17** of 1937, Department of Agriculture, C.P. and Berar.

[10] Tambe, G. C. and Wad, Y. D. (1938). *Agriculture and Livestock in India*, **8**,397

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CHAMBAL RAVINES RECLAMATION SCHEME *

BY A. P. F. HAMILTON,

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There is ravine land adjoining most of the rivers in Gwalior State, but the Chambal is the worst offender. Many thousands of acres of cultivable land have been destroyed and the ravines continue to cut back into plateau cultivation. In Bhind and Morena districts the damage is most severe, the increasing drainage of water from the subsoil is causing the fall of the spring level in wells.

As the result of the recommendations of a commission, an afforestation scheme was begun in 1925.

The objects of the operations were :—

(1) Prevention of erosion.

(2) Provision of firewood, small timber and fodder for the local population.

(3) The scheme was expected to show a profit.

It was, I think, rather a tall order to expect the scheme to show a profit as well as achieve the other two objects under a combination of soil and climate conditions which would be avoided like the plague by anyone who wished to invest his money in forestry. It is early to judge the financial results as the crop is not yet mature, but already one quarter of the total cost to date has been recovered by income and I have little doubt that the whole outlay will be paid back and that subsequently a net annual profit will be realised. And this is more than an investor would expect; for his capital is converted into the growing stock and the improved value of the land and he would then be satisfied with the interest on his capital or the net value of the annual sale of forest produce.

Non-recurring and recurring expenditure up to 1944-45 amounted to Rs. 1,19,651. Income to the same date has been Rs. 30,467.

The area included in the scheme lies in two blocks :—

Kunwari block	..	912 acres.
Barai block	..	1,279 acres
Total	..	2,191 acres.

Operations began in 1925-26, but were stopped in 1929-30, and only 1,283 acres were reclaimed and afforested. Maintenance staff has been retained and a certain amount of restocking blanks and tending has been done from time to time.

The total cost per acre to date amounts to Rs. 81/- per acre.

A gazetted officer, Mr. Rahalkar, was in charge of the work for ten years; during the afforestation work in progress he had under him two rangers and 4 forest guards, later the staff was reduced.

Sufficient time has elapsed to judge whether the scheme has been a success. As regards erosion control, success may be rated at 100 per cent., except for the extremities of the ravines where erosion could only have been stopped completely if the runoff from the fields had been controlled at the same time. In the Kunwari block surrounding cultivation has been entirely saved from erosion by the reclamation work. The crop has not yet completely matured and up to the present only dead wood and ordinary thinnings have been made. These have, however, produced a useful supply of firewood and much more will now be available since the *shisham* which provides the main crop is now ready for felling. A most luxuriant growth of grass is produced, but full advantage of it is not taken by the villagers.

* *Vide* my tour notes of Gwalior State.

The Chambal ravines cut far back from the river into a high plateau of good cultivation. They are generally narrow and steep-sided, but a few are wide. The subsoil has one or two impermeable white clay layers and there is much *kankar*; the soil is generally unfavourable for tree growth. During the summer the heat is intense, and the average annual rainfall is 22 inches. When operations began the ravines were like the rest of the unreclaimed country to-day, a sea of brown ridges and troughs with a few browsed relics of the following desert species: *Capparis aphylla, Salvadora oleoides, Acacia leucophloea, Balanites roxburghii, Zizyphus jujuba.*

Cattle grazing was heavy.

The reclaimed areas were fenced where necessary and closed to grazing. The forest crops were established on contour trenches. In the ravines 216 earthen bunds with escapes were constructed; the highest, 27 feet, has now silted up to a height of 12 feet. There have been few breaches. No control measures were taken on the cultivation above the bunds.

The following species were selected for afforestation :—

> *Shisham* (*Dalbergia sissoo*) *Babul* (*Acacia arabica*), *Teak* (*Gmelina arborca*), *Siris* (*Albizzia lebbek*), *Prosopis juliflora* (*arid*), *Prosopis spicigera, Anogeissus pendula, Khair* (*Acacia catechu*), *Dendrocalamus strictus, Pongamia glabra*, and *Baib* or *sabai* grass (*Eulaliobium binata*).

Mulberry stumps have recently been planted under *shisham* in the ravine beds.

The following species have not proved successful :—

> *Anogeissus pendula, Babul, Dendrocalamus strictus*, and *Pongamia glabra*;

and may as well be given up.

As I have already indicated, the soil and climate conditions are most unfavourable for afforestation and it is therefore not unexpected that some of the species which have been tried have failed. All the same the stock of utilisable timber is not inconsiderable and this applies particularly to *shisham* which has done quite well in the ravine bottoms. It is true that *shisham* is in many places dying out but it has produced trees of firewood size in a period of 16 to 18 years and that is some achievement. Teak and *Gmelina arborea* have also done quite well; *Prosopis juliflora* is also doing very well and its extension as the main species in the less favourable localities is indicated. It will produce small firewood in the less favourable situations and I strongly advise its propagation on a wide scale.

Dichrostachya cinera is coming in naturally all over the slopes; it will produce firewood of good quality but small size. Full use should be made of this species for firewood.

I suggest that the following species also be tried :.—

> *Acacia senegal* (on the slopes and table land), *Melia azedarach, Azadirachta indica* and *Butea frondosa*.

Melia ought to succeed where *shisham* fails, as it does well in the Punjab plains on unfavourable alluvium soils similar to that of the Chambal.

As regards fellings in the Kunwari block, I would suggest the following action. The blanks which have appeared in the *shisham* crop should be widened to make them sufficiently large for restocking with *shisham, Gmelina arborea* and *Melia azedarach*; but where *shisham* still remains in healthy canopied groups, the groups should be thinned and left to grow until they produce more timber or show signs of dying.

There can be no question of any system which approaches clear felling of the whole area and a degree of irregularity in the crops is an advantage. The only necessity is that the openings to be restocked must be sufficiently wide to give full light for the new crop.

To sum up, I consider that success has been proved beyond doubt and that the state may, without hesitation, adopt the scheme which has been prepared for the reclamation of the rest of the ravine area. I have examined the scheme and in my opinion it is sound.

I was informed by Professor Mukerjee, economic adviser to the Gwalior state, that a plan for soil conservation of the cultivation on the plateau above the ravines submitted by him has received the sanction of the Gwalior Darbar. This scheme is really an integral part of the whole plan of soil conservation for this tract, and operations on both the cultivated plateau and the ravines should be coordinated. In a scheme of this nature the control of runoff must begin at the top and there should be one authority coordinating the whole scheme. As things are, it would

be better that the forest department should carry out the measures required in the cultivation as well as the ravines; but it is desirable to train agriculturists to take their part in schemes of this nature. There are said to be 750 square miles of ravine land, so there is much to be done.

The work in cultivation would include survey and *bund* construction in both of which forest department officers have a certain amount of training and it was for this very reason that in Bombay the execution of *bunding* schemes was, to begin with, entrusted to officers of the forest department until such time as others could be trained. Topographical conditions in the cultivation are eminently suitable for contour *bunding* and I would advise this method of soil conservation in preference to terracing.

Organisation. I understand from the conservator of forests that it is his intention that the officer in charge of reclamation should also be in charge of afforestation of the canal plantations and the establishment of minor forests in the rural development scheme. If these duties are added to the very considerable work of reclaiming an area of about 60,000 acres in the two districts of Bhind and Morena, there is every justification for the formation of an afforestation division complete in itself. I have personal experience of work of this nature and I know that as compared with the work of an ordinary territorial division, it is far more exacting. For all work of this nature only an officer of drive and experience should be employed.

In both the districts of Bhind and Morena there is a shortage of grazing; although the ravines provide grazing, which is only grazing in name, the local villagers are likely, until they become accustomed to it, to object to the necessary closure. Closure will, however, produce a quantity of grass considerably in excess of what the animals are able to find by grazing and it is only that the people are too lazy or are not accustomed to cutting grass that they prefer to graze. The following concessions might, however, be permitted in addition to the fact that the area will only be closed progressively:—

(1) Grass cutting might be allowed earlier in the season than at present.

(2) The grazing of essential cattle, *e.g.*, plough bullocks and one or two cows based on number of ploughs to be allowed grazing in areas in which regeneration is considered to be sufficiently established, and then only for a few months during the dry season. *But unlimited grazing must never be allowed on these friable soils ;* it must be very strictly limited, for otherwise the money which government has spent will be wasted through the destruction of the plantation.

In these two districts the shortage of firewood is more acute than I have met in any other locality in India. The production of firewood is, therefore, as important an object of management as that of erosion control. The local people must be made to realise the importance of the plantations and the silvicultural treatment of the forest crops must be such as to provide a sustained yield of firewood.

If I may be premitted to do so, I would like to conclude this paragraph with a special word of congratulation for Mr. Rahalkar on the success of the first stage of the Chambal reclamation. He has devoted several years of his service on this arduous and thankless task; by pointing the way to the defeat of a real menace to the State, he is deserving of great praise.

THE EFFICIENCY OF ENUMERATIONS *

By A. L. Griffith, D.Sc.

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Introduction

The sixth silvicultural conference held in Dehra Dun in April 1945 discussed the subject of the efficiency of enumerations and adopted the following resolution :—

RESOLUTION ON ITEM 4.

WHEREAS

(1) The general overfelling of the forests of India and in particular the felling of special sizes of selected species for war purposes has rendered it imperative that as soon as the war is over large scale enumerations be done in a number of provinces for working plan purposes in order to estimate war damage and remaining resources.

(2) Enumerations will also be necessary to provide for post-war planning.

(3) The accuracy of enumerations is a matter of permanent importance.

(4) At present we have little or no information of the potential accuracy of current methods of enumeration.

(5) It appears probable that much useful information can be obtained fairly quickly by examination of existing data.

THIS CONFERENCE RESOLVES THAT—

(1) *The central silviculturist be authorised to proceed at once with the examination of existing data to endeavour to give an indication as soon as possible of the probable accuracy of different methods and intensities of enumeration in different types of forest and terrain.*

(2) *Approximate information is needed quickly rather than a more detailed accurate complete research.*

(3) *The staff used for enumeration work should be of the highest quality available, and should receive extra remuneration.*

(4) *After the examination of this data a paper or leaflet should be written on the necessity for determining the precision of sampling enumerations.*

As a result of this resolution we started the analysis of whatever enumeration data existed. At the outset it is necessary to emphasise that in enumeration work there are in general two kinds of errors :—

(a) the errors of the enumerating party.
(b) the errors of the method of enumeration.

The errors of the enumerating party are a purely local concern and are due to such factors as inexperienced staff, ill adjusted instruments, and lack of supervision, etc. This investigation is only concerned with the second type of error that is due to the method of enumeration but of course every endeavour should be made by the working plan officer to see that the personal errors of his enumerating parties are reduced to a minimum.

We must however point out that in the past these personal errors have sometimes been very large and often due to attempts to carry out the enumerations too cheaply. Further it is not generally realised that these errors of the enumerating party are likely to occur to the same extent in the final result of the enumeration irrespective of the percentage of the area which is enumerated. For example, if the party makes errors of 50 per cent, this error will occur to the extent of 50 per cent. in the final figure whether the party enumerates 1 per cent. or 100 per cent. of the area.

Practical aspect of the investigation

We started by analysing the data of a compact area of 791 acres of Madras wet evergreen forest in which the commercial timber volume was known on every acre. This data had been collected 20 years ago with no idea at the time of using it for such an analysis. For convenience the base line had been run roughly along the contours and the enumerated strips at right angles to the base line or roughly across the contours.

The analysis at once showed us two very striking facts. Firstly the acre volumes were not arranged at random on the ground but for all practical purposes they were arranged systematically according to altitude. That is to say there was a major fertility gradient in the direction of the strips (*i.e.*, across the contours). There was also a minor fertility gradient along the contour (*i.e.* across the strips) but this was due to the base line only roughly following the contours and is of little practical importance. Secondly it was at once apparent that to get an estimate of the total volume sufficiently accurate and precise for all practical working plan purposes it was not necessary to carry out an expensive 100 per cent.

*Paper read at the 7th Silvicultural Conference (1946), Dehra Dun, on item 7—The Efficiency of Enumerations.

enumeration for a 5 per cent. or 10 per cent. sampling was all that was required.

We followed this up by analysing the data of the commercial timber volume of two areas of 2212.5 and 7383 acres of Madras mixed moist deciduous forest and found our evergreen indications confirmed. The volume data was arranged by nature systematically and a 5 per cent. or 10 per cent. enumeration was all that was necessary for practical purposes.

We had so far only dealt with the total commercial timber volume of the whole forest in two different forest types, each of which enumerated a number of different species. We therefore went on to consider the total volume in a *chir* (*Pinus longifolia*) forest which is one species in an almost pure forest, and then to the volume data of a *sal* (*Shorea robusta*) area which although not a pure forest is one in which the *sal* definitely preponderates in the type to the extent of about 80 to 90 per cent. Again our two main indications were confirmed.

In addition, in order to get a visual picture of what this volume data looked like, and to confirm our mathematical indications of fertility gradients, large scale maps were made of the different areas. The volumes were arranged in five sets of volume classes and each class represented by a different colour. The heavy volumes were represented by heavy colours such as black and blue and the light volumes by light colours such as pink and white. Each acre was coloured with the appropriate tint. In this way the volume gradients were at once apparent to the eye.

In a working plan, we often want to know fairly accurately not only the volume of one species in a mixed forest where it only forms a comparatively small part of the crop but we also want to know the distribution of the size classes of that one species. In our investigation, we therefore went back to the Madras deciduous forest and reanalysed it for the teak data only and for the different size classes of this one species which only formed 29 per cent. of the commercial crop.

We not only showed that a 5 per cent. or 10 per cent. enumeration was sufficient for practical purposes when dealing with the one species but it was also sufficient when dealing with only one size class of that one species. The doubtful size class was that of the large overmature trees for these are very few and far between and unevenly scattered over the forest and hence unlikely to be sampled adequately by a small percentage of sampling.

It is however emphasised that these results only apply to comparatively large areas. When dealing with a small annual coupe of say a few hundred acres of course a full enumeration of the area should be done.

The conference resolution asked for quick publication of tentative indications as soon as possible. We therefore issued leaflets as the work progressed. These leaflets are not the last word of a finished piece of research but are merely an attempt to circulate approximate practical information quickly. When the work is finished it will be written up as an Indian Forest Record. The leaflets so far published are :—

Leaflet No. 83 I.	The problem.
Leaflet No. 84 II.	Madras tropical wet evergreen forest.
III.	Typical calculations.
Leaflet No. 85 IV.	Madras moist mixed deciduous forest.
Leaflet No. 86 V.	Upper Assam tropical evergreen forest.
VI.	Typical calculations (continued).
Leaflet No. 87 VII.	The distribution of the volume figures.
Leaflet No. 88 VIII.	*Chir* (*Pinus longifolia*) forest in the Punjab and United Provinces.
Leaflet No. 89 IX.	The distribution of the volume figures (continued).
Leaflet No. 90 X.	Hill *sal* (*Shorea robusta*) forest in the United Provinces.
Leaflet No. 91 XI.	The distribution of the volume figures (continued).
Leaflet No. 93 XII.	One species in a mixed forest (teak in a Madras moist mixed deciduous forest).
XIII.	Confirmation of *chir* (*Pinus longifolia*) and *sal* (*Shorea robusta*) data.
XIV.	Summary of indications.

Summary of indications

The following indications can be seen from the work so far done:—

(1) Intensive and expensive 100 per cent. enumerations are NOT necessary in order to obtain a reasonable estimate of the growing stock even when we are dealing with the individual size classes of only one species in a mixed forest where that species forms some one quarter to one third of the crop. For practical purposes enumerations of 5 per cent. to 10 per cent. are probably sufficient.

(2) Systematic sampling in general gives us rather more accurate and more precise estimates than random sampling provided it is carried out with a full appreciation of the probable trends of the fertility gradients of the forest.

(3) Whatever the intensity and area of the enumeration, some 200 ultimate sampling units (*i.e.*, separate estimates of the volume per acre) are necessary to calculate an estimate of our precision within reasonable limits. Experience has shown that at least some 5 to 10 separate estimates per square mile should be used. This gives economically reasonable numbers of figures for the computors to calculate with.

(4) In an average province with a working plans circle dealing with the preparation and revision of some 6 to 10 working plans a year, one computor and one assistant computor could probably deal with all the necessary computing work.

(5) In all the five cases so far examined the volume figures are not normal distributions. They show both positive skewness and positive kurtosis. This departure from normality is however not sufficient to vitiate the application of the normal laws of probability and it has been shown that it is justifiable to treat the volume figures as though they are normally distributed.

Practical applications of the work

These indications began to appear just before this last working season started and systematic partial sampling has been carried out this year in a number of provinces such as the United Provinces, Central Provinces, Bombay and Assam. The data analysis results were few at the time that field work had to be started and current practice in the various provinces has differed. Partial sampling enumeration was new as a practical proposition, and while some provinces decided to accept the early tentative results and do 5 per cent. sampling other provinces were much more cautious and decided on 20 or 25 per cent. enumerations. A typical example was that of the United Provinces who decided at a meeting of conservators in September 1945, as a measure of caution to enumerate 10 per cent. for hill *sal* selection working circles, 20 per cent. for plains *sal* selection working circles and unallotted P. Bs. in *sal* conversion working circles, and 25 per cent. for P. B. I in *sal* conversion working circles.

This last working season is probably the most important we have ever had for being the first since the war ended, all over India we have been trying to repair the ravages of the war and prepare temporary working schemes and revise most of our working plans.

As an example of what has been accomplished with the aid of the results of these enumerations analyses I quote the report of the United Provinces which is the only one available at the time of writing this note.

"In the 1945/46 working season the U. P. working plans branch carried out systematic partial enumerations over an aggregate (nett) area of 36,379 acres in connection with the revision of 3 major working plans and the preparation of interim working schemes. The corresponding gross area of *sal* forests sampled in the *bhabar*, submontane and Gangetic alluvial tracts of the U. P. amounted to no less than 2,44,165 acres. It will thus be realised that it would have been quite impossible under post-war conditions to have carried out such a gigantic programme by means of total (100 per cent.) enumerations for the purpose of assessing the post-war growing stock and basing thereon the necessary immediate recalculations of yield prescriptions within the short space of only one working season. That the full programme of enumerations under the new system was practically completed (including all necessary checks) by the middle of March, 1946 in sufficient time to permit comprehensive interim schemes to be worked out, sanctioned, and markings done under the prescriptions thereof in *the same working season* provides ample justification for adopting the methods advocated by the forest research institute".

Speed and cost of partial enumerations

The rate of progress and the cost of a partial enumeration, of course, depend on the type of forest, the terrain, the intensity of sampling, the efficiency of the enumerating party and particularly with the capabilities of the man in charge. We have now the experience of one full working season in a number of provinces and at the enumerations course, the various delegates discussed their methods and progress for a number of types of forest. One of the great variations was in the constitu-

tion of an enumerating party and in the actual arrangement of the party while at work in the forest.

A very general summary of the actual work done and the opinions of the various working plan officers in charge of parties is that a 5 to 10 per cent. enumeration under average conditions can cover a nett area of about 20 to 35 acres per day (*i.e.*, sampling a gross area of from 200 to 700 acres per day). In general such a partial enumeration costs about one-third as much as a full enumeration and takes about one quarter of the time to do.

Enumerations course at Dehra Dun

The end of the war found all provinces with a greatly depleted and diluted forest staff, many of whom were untrained technically. They had spent the war doing a very fine job of felling and extraction, etc., but they were either technically rusty or unqualified for the urgent post-war works of getting our forest management back to normal. At the request of the provinces and in spite of great difficulties of food, accommodation, etc., we held a course of instruction in partial enumerations at the forest research institute in March, 1946. This was attended by 13 officers and 12 rangers from 9 provinces. Preliminary lectures were given and these were followed by actual enumerations by a number of methods in the *chir* pine plantations at New Forest. Particular attention was paid to the errors likely to occur in practical work.

Mathematical aspect of the investigation

It is necessary to comment on the mathematical aspect of the work although this is not really of so much interest to the ordinary district forest officer as the practical aspect. Owing to the errors of the enumerating party even a full 100 per cent. enumeration only gives us an *estimate* of the growing stock and we *never know the true value*. Similarly a partial enumeration only gives us an estimate and this is an estimate that we know even less about than that of a 100 per cent. enumeration. It is therefore essential to work out how far we can rely on the estimates we produce.

From the 100 per cent. enumeration data analysis we worked out the probable errors that would occur in partial sampling of various intensities. From the actual figures of our partial enumerations we had to endeavour to work out the probable limits of accuracy of our estimate or in other words *the precision of our estimate.*

It must be emphasised right at the beginning that we had nothing to go on and had to evolve our own methods. In addition the silvicultural conference had particularly asked for approximate results quickly.

The data was arranged by nature systematically and hence the only logical way to sample it was in a systematic manner. (By trial it was quickly found that systematic sampling gave better results than random sampling). We tested the distribution of the volume figures and found that they were not normally distributed. The frequency curves showed positive skewness and positive kurtosis. In other words this means that the curve was not symmetrical but was lop-sided, and also that the most frequently occurring volume was not the mean volume but slightly less than the mean volume (*vide* curve on p. 4 Leaflet No. 87). We worked out the "probability integral" for all the skew volume distribution curves and for both the postitive and negative portions of them. This was also worked out for the theoretical normal curves derived from these skew curves.

The results showed that for all practical working plan purposes the extent of the skewness and kurtosis was not sufficient to vitiate the application of the normal laws of probability to them.

In default of any obvious method more suitable, in order to work out a precision for our estimates, we applied the statistical methods evolved for the analysis of random samples to the systematically arranged data of the partial enumerations. We were forced to do this because statistical methods applicable to the systematic sampling of systematically arranged data have never been worked out.

The practical uses and applications of the work have been completely proved but it is essential that our mathematical methods of calculating the precision of our estimates should be the best possible.

We have been in consultation with the Indian laboratory of statistics at Calcutta (under Prof. Mahalanobis), with Mr. Finney (Lecturer in the design and analysis of scientific experiment at Oxford) through the Professor of Forestry (Prof. Champion) and with Dr. Yates

(of Rothamstead Experiment Station). Several alternative methods have been suggested and are under examination by the statisticians.

It must therefore be realised that we have not yet decided on the best and most valid method of carrying out the actual calculations of our precision. I would however bring to notice that the actual precision as calculated by the various methods so far suggested and considered show comparatively small differences and hence make little or no practical difference to a working plans officer. In addition it should be emphasised that we are calculating the limits of our precision at the 5 per cent. and 1 per cent. levels and with all the methods we have used and with all the examples we have calculated (and they now total over 100), in only one case so far has the actual error been greater than the calculated limits of precision at the 5 per cent. (1 in 20) chance level. In no case so far has the actual error been greater than the limits calculated at the 1 per cent. chance level. *This clearly demonstrates that even if we have not yet found the best method we are not far from it and actually we are near enough for all practical purposes.* We must go on until we completely satisfy the mathematicians but this does not affect the practical forest officer.

The precision of yield formulae

The enumeration results are in practice used to calculate the permissible yield. In some provinces this is done by using a formula which includes factors other than the enumeration results. It would be of little use carrying out enumerations with an accuracy of say $\pm$ 5 per cent. if their combination with these other factors of doubtful accuracy resulted in a yield figure with an error of say $\pm$100 per cent.

One of the commonest formulae is that used in the United Provinces, and we took as an example the Haldwani division hill *sal* working circle in the 1937/38 to 1951/52 working plan of 1937 as this is one of those at present being revised owing to the war. This states :—

"The yield of selection trees is based on Smythies' formula which defines the yield available during the felling cycle as the number of trees of the next lower diameter class that may be expected to grow up to the exploitable size in the felling cycle, *i.e.*,

$$x = \frac{f}{t}\,(II - Z\% \text{ of } II)$$

where x = yield, *i.e.*, the actual number of 16 to 20 inch class trees which survive and pass into the 20 inch and over class during the felling cycle.

f = felling cycle = 15 years.

t = the period that II takes to grow to exploitable size (and this in practice means the average time in years it takes for a 16 inch tree to grow to 20 inches and not the mean of the class, an 18 inch tree to grow to the mean of the next class, 22 inches—*author*).

II = the number of trees in the 16 to 20 inch class (a figure estimated by enumerations— *author*).

Z = the mortality percentage *i. e.*, the percentage of II class trees that disappear in "t" years.

"The annual yield is expressed as the percentage of the saleable selection trees present in the coupe at the time of marking by the following formula :—

$$Y = \left(\frac{x}{I + \frac{x}{2}}\right) 100$$

where I = the number of trees of and above 20 inches diameter (a figure estimated by enumerations—*author*).

The question at once arises, what is the accuracy of Y. The felling cycle "f" is fixed and I and II are estimated by enumerations for which the accuracy can be estimated from the calculated precision of the enumerations. No data to determine "Z" and "t" accurately exist. They were first estimated from HOWARD'S original yield tables and later from GRIFFITH & SANT RAM'S revised tables and this is the best that can be done at present although it is not correct to apply the data of uniform crops to selection crops. Linear observation plots have been in existence for 9 years to determine 'Z' and 't' but only 3 measurements have so far been made and these are not enough for the purpose. At least another 2 measurements will have to be made before sufficient evidence is collected from these plots to estimate 'Z' and 't' with any degree of accuracy.

In consultation with the working plans conservator U.P., we therefore assumed the probable accuracy of the various factors as being used at present and worked out the resulting probable accuracy of 'Y'.

Thus, using the Haldwani figures of the 1937 working plan :—

A. If	I is within		$\pm$ 10 %
	II is within		$\pm$ 10 %
	t	=	30 $\pm$ 5
and	Z	=	33 $\pm$ 5
then	Y	=	53 % $\pm$ 12 %

B. If	I is within		$\pm$ 10 %
	II is within		$\pm$ 10 %
	t	=	30 $\pm$ 7.5
and	Z	=	33 $\pm$ 7.5
then	Y	=	53 % $\pm$ 16 %

This is obviously sufficient for ordinary working plan purposes BUT the precision of Y depends on whether I, II 't' and Z are ALL within the limits we have assumed. If ANY ONE of them is not within these limits then Y is not necessarily within the limits calculated above.

Conclusions

The above gives a general outline of the progress of the investigation so far and the way in which it has been applied in practice in the working season just concluded. It is hoped that the conference will discuss it in detail and adopt a resolution which will include indications of the directions in which we are to proceed with further work in order that the forest research institute may give maximum help to the provinces.

I ask the conference to realize that it has been a rush job to accomplish this work in a year, particularly with our shortage of staff and I would draw attention to the fact that the provinces have still not produced an assistant silviculturist or a statistical assistant for the silviculture branch of the forest research institute and during the last year although suitable men exist for the posts, on three occasions provinces have refused to release them. The work of the experimental assistant silviculturist (Mr. Prasad) who is having to carry on with the work of the statistical assistant silviculturist as well as his own work, and that of the computing staff and the surveyor has been excellent and deserves recognition by the conference.

PREVENTION AND CONTROL OF INSECT BORERS AND FUNGAL STAINS AND DECAY OF THE TIMBER OF MALABODA (MYRISTICA DACTYLOIDES GAERTH)

By C. H. Holmes

(*Silviculturist, Ceylon*)

SUMMARY—MALABODA is a large stately tree rather common in distribution in the wet evergreen forests of the south-western quarter of the Island. It regenerates itself fairly readily and naturally following exploitation of such forests. The timber merits more extended use but is non-durable and subject to borers under ordinary conditions.

In the course of these investigations concerned with the prevention of insect borers and fungal decay 7 different species of beetles and one fungus have been identified as being mainly responsible.

Experiments of surface coating logs, barked or unbarked with selected preservatives have shewn that none are really of any use. Stacking logs well above ground was found to give no advantage. Unbarked logs are more heavily infested by borers than barked logs. All logs no matter how treated decayed beyond possibility of their being put to any use whatsoever within 6 months of felling when left under forest conditions.

Logs kept immersed in water remained sound and free of any borers or decay only so long as they remained in the water. They became so affected when removed and exposed to infection even after a period of six months in water.

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Logs kept immersed in water remained sound and free of any borers or decay only so long as they remained in the water. They became so affected when removed and exposed to infection even after a period of six months in water.

In the case of sawn timber all decay and borer infestation can be satisfactorily prevented by brush coating with or momentary steeping in baths of any of the following preservatives:—

(*i*) Lime-Wash.

(*ii*) 10 per cent. hot aqueous solution of Borax.

(*iii*) Cold aqueous solution of Ascu (¼ lb. per gallon).

(*iv*) 5 per cent. aqueous solution of Sodium silico-fluoride.

(*v*) 1 per cent. aqueous suspension of Gammexane P.C. 1147.

(*vi*) 2 per cent. petrol solution of Gammexane P.C. 982 and

(*vii*) 1 per cent. petrol solution of D.D.T.

Choice of preservative to be used will depend on the uses to which such sawn material is finally to be put. Treatment must be done immediately after felling and sawing. One infestation has been allowed to take place by even a few days delay between these operations surface treatment of any kind is futile.

A trial has been made to obtain indications of how tea chests constructed from successfully treated planks would stand up to actual use. 10 such chests were with the Tea Commissioner for a year during which they travelled approximately 750 miles and spent 6½ to 7½ months in storage packed with tea. Examined at the end of this period of use it was found Borax and Sodium silico-fluoride had provided adequate protection even though treated planks had been lightly planed in making up to boxes. It should have been better if hot instead of cold solutions had been used also in the case of other preservatives as for Borax. Treated planks sprayed periodically remained free of borers in the case of all planks so tried.

Since insect borers are attracted by and depend for their sustenance mainly on the starch and sugar contents of the wood it has been sought to make trees exhaust all their available food resources before being felled and sawn. This has been attempted by deep sub-crown and base girdling. Planks from trees felled up to 11 months from initial girdling were found susceptible to borer infestation in due course. The planks from the top end log of the last tree to be felled at the end of 19 months from initial girdling have been found much less affected than planks from other sections of the same tree. This interesting line of investigation is being continued.

Introduction

Malaboda is amongst the largest and best formed trees of the Tropical wet evergreen high forests of Ceylon. Trees of this species go up to 7 to 8 feet in girth, reach heights of well over 100 feet and generally have clean, straight, tall cylindric boles of truly majestic appearance. Common and found widely distributed in the wet zone, *malaboda* regenerates itself quite readily in felling gaps. It is one of the commoner timber species to be found in natural regeneration following the so called "coppice" exploitation *i.e.*, in practice clear felling without burning carried out in certain of the subcoastal forests of the south-western quarter of the island.

The Timber :

The Timber planes clean. It is straight grained, fine and even textured. Moderately light in weight—(24 lbs. per cubic foot—Lewis; 34 lbs. per cubic foot—Bourdillon). It is a pleasing light pinkish yellow brown in colour turning a straw-brown with exposure. It is free from any odour or unpleasant taste. The colonial forest resources development department of the colonial office, London, to whom a log of *malaboda* had been sent reported in 1938 that the timber "peeled easily, presented no difficulties in manufacture and was quite suitable for making into plywood". It is also considered specially suitable for tea chests.

Its Defects :

So, both from the silvicultural and timber utilisation standpoints *malaboda* deserves better recognition than it gets in general use. Unfortunately, there are two very undesirable characteristics of the timber which militate against its utility—*viz :* susceptibility to (a) wood borers and (b) discolouration and decay by fungi. The colonial forest resources development department commented on this and said that the log received by them was "badly discoloured and damaged by borers". This has also been the experience of the local plywood factory at Gintota which does not, therefore, now accept *malaboda*. Certain specimens of the timber received at the head

office of the forest department for identification were so consumed by innumerable coleopterous borers that they swelled up, burst and disintegrated into powder when immersed in water, leaving only thin outer shells of wood!

Agents responsible :

Collections were made from time to time, in the course of these investigations, of beetles and fungal fructifications found on the logs and planks under observation. Amongst the beetles the following were identified with the kind assistance of Dr. C. F. C. Beeson and Mr. J. C. M. Gardner—Entomologists of the Forest Research Institute, Dehra Dun:

1. *Xyleborus semigranosus* Bldfd.— Scolytidae (Ambrosid—Pin hole).
2. *Phleosinus detersus* Chap.— Scolytidae (Powder Post—Pin hole).
3. *Minthea rugicollis* Wlk.— Bostrychidae (Powder Post—Pin hole).
4. *Heterobostrychus aequalis* Waterh.— Bostrychidae (Shot hole).
5. *Xylothrips flavipes* Illiger.— Bostrychidae (Shot hole).
6. *Crossotarsus minax* Wlk.— Platypodidae (Shot hole—Ambrosid).
7. *Tarsostenus univittatus* Rosi.— Cleridae (Predator on certain of the above).
8. *Batocera rubus*. Linn.— Cerambycidae (Large longicorn).

Amongst the fungi the chief, responsible for decay of logs, appears to be *Polystictus oestreiformis* Berk, for the identification of which I am indebted to Mr. L. S. Bertus of the department of agriculture.

Early Experiments

With a view to investigating the possibilities of effecting some control over the incidence of borers and preventing discolouration of the timber by fungi a preliminary exploratory set of experiments were carried out by the divisional forest officer, south western division, in March and April, 1940. 3 selected trees of *malaboda* were felled in the first set of trials and 2 for the second set of trials. Each tree was logged into 6 equal lengths and each log given one of the following treatments:—

a. Unbarked—left on ground.

b. Unbarked—left raised 1 foot above ground.

c. Barked—untreated—left on ground.

d. Barked —untreated—raised 1 foot above ground.

e. Barked —brush coated with a solution of sodium arsenite (strength unknown)—left on ground.

f. Barked —brush coated with a solution of sodium arsenite (strength unknown)—raised 1 foot above ground.

To test the popular belief that incidence of borers is less if trees are felled on the waning moon and more on the waxing moon, the first 3 trees were felled on the waxing moon (March 8, 1940) and the other 2 trees on the waning moon (April 26, 1940).

All logs irrespective of treatment were found attacked by borers on the 11th day after felling, logging and treatment in the first set of trials; and, after the 7th day in the second set of trials. Counts of bores were taken on 6 ins. squares at the butt and top ends (presumably on the upper surfaces) but these meagre figures failed to bring out any definite differences as between treatments—except, perhaps, to show infestation in all cases was relatively heavy.

More carefully planned and comprehensive sets of experiments were undertaken at Indikade

in March 1942, and repeated in April 1943, with :—

a. 10 feet logs of 3 to 4 ft. mid-girth (over bark)—barked and unbarked—stacked on the ground on 6 in. diameter runners of Milla and raised on trestles 2 ft. above ground. 56 logs were used in these experiments 28 each year.

b. 4 logs of similar girth and lengths to above --2 barked and 2 unbarked—immersed in a running stream—in 1942 and 4 logs each in the 1943 set of trials.

c. 36 sawn planks 6 in. x 1 in. x 10 ft. stacked as for air seasoning with 1 in. stickers in 1942 and 72 plants 6 in. x 1 in. x 10 ft. half stacked with 1 in. stickers and half with 2 inch stickers in 1943.

When the first set of logs were carefully examined for borers 7-8 days from felling and logging, borer infestation was discovered to have commenced. The few bores found were sterilised by treating them individually with a 4 per cent. solution of *para dichlorobenzene* in light crude oil. In most cases the borers soon backed out of the burrows they were just commencing and were collected for identification.

Experiments with logs in the open:

The following different treatments were given to the logs in the first set of experiments. Each log was divided equally and treatments were given at random, replicated twice, one to each half of a log. The first 5 treatments were given to both barked and unbarked logs and the last 2 treatments to barked logs alone, which for that reason were 2 more in number.

1. Control—untreated.

2. Hand-coated twice with fresh *cowdung* made up with water to the consistency of a thick cream.

3. Given 2 brush coats of limewash (with glue as sizing) as used in ordinary whitewashing.

4. Given 2 brush coats of *light crude oil* (the second coat on the day following the first).

5. Given 2 brush coats of a 4 *per cent. solution of paradichlorobenzene in light crude oil* (the second coat on the day following the first).

6. Given 1 brush coat of an *aqueous solution of Ascu* ($\frac{1}{4}$ *lb./1 gallon*).

7. Given 1 brush coat of an *aqueous solution of borax* (10%) *heated to boiling point.*

It was found even at the time of treatment that the *light crude oil* was very volatile and so, unlikely to remain effective for long. The logs were, therefore, sponged over with a strong solution of p-dichlorobenzene in petrol exactly 20 days after initial treatment and given *one brush coat of thin tar* supplied by the Colombo Gas & Water Co., Ltd. Treatments 2 and 3 were repeated again a week after original treatment, as the first coats had been washed away by rain and drip from the trees under which the logs were stacked. In the 1943 experiments treatments 4 and 5 were omitted as unsuitable and treatment 4 replaced by a single liberal brush coat of thin tar.

Counts of bores classified according to size into *pin holes* and *shot holes* were taken at approximately weekly intervals for the first month after treatment and approximately monthly intervals thereafter up to the end of the 6th month in 1942 and 3rd month in 1943. These counts were taken from 2 inch wide indicator strips marked by tintacks—commencing and terminating 6 inches from the ends of each treatment half of a log and placed on the upper and lower sides of the logs as well as on the flanks. After each count, logs were turned back so that their original positions were maintained unchanged throughout the period of observations.

The results of these counts tabulated for the first to the third month and sixth month to bring out :—(a) possible special treatment effects and (b) differences observed on logs stacked 6 in. and 2 ft. above ground are shewn in *Table I* on page 111. Three of the set of barked logs were unfortunately lost through flooding in May 1940, of the stream running by the stacking ground. Fortunately this did not involve the loss of both replications of any one treatment.

TABLE I—SUMMARY OF COUNTS OF BORES ON LOGS

Treatment	Year	Logs raised 2 ft. off ground				Logs raised 6 in. off ground				3 months Total.	
		May 1st month. P S	June 2nd month. P S	July 3rd month. P S	Oct. 6th month. P S	May 1st month. P S	June 2nd month. P S	July 3rd month. P S	Oct. 6th month. P S	1942	1943
Barked Logs: 1. Untreated Control	1942	7 16 23	38 21 59	63 21 84	131 24 155/15	26 7 33	49 9 58	131 12 143	192 29 221/22	$\frac{227}{11}$	
	1943	19 12 31	27 15 42	69 20 89	.. ..	16 12 28	27 12 39	59 14 73	..		$\frac{162}{8}$
2. Cowdung	1942	19 7 26	30 9 39	57 11 68	81 16 97/9	23 1 24	60* 1 61	74* 6 80	110* 10 120/12	$\frac{148}{7}$	
	1943	31 10 41	33 10 43	42 14 56	.. ..	34 1 35	48 2 50	62 13 65	..		$\frac{121}{6}$
3. Lime Wash	1942	48 8 56	65 14 79	89 24 113	118 31 149/14	18 7 25	64* 8 72	110* 10 120	118* 18 136/13	$\frac{233}{12}$	
	1943	15 4 19	31 8 39	67 14 81	.. ..	19 5 24	24 7 31	51 13 64	..		$\frac{145}{7}$
4. Crude Oil/ Thin Tar	1942	4 3 7	6 3 9	18 6 24	32 8 40/4	0 1 1	18 2 20	38 6 44	90 18 108/10	$\frac{68}{4}$	
	1943	0 0 0	0 2 2	15 5 20	.. ..	1 0 1	5 1 6	19 8 27	..		$\frac{47}{3}$
5. P.dichloro-benzene in Crude Oil	1942	2 2* 4	14 2 16	70* 6 76	140* 14 154/15	7 3 10	19+ 7 26	48+ 7 55	110 13 123/12	$\frac{131}{7}$	
6. Ascu	1942	17 8 25	27 16 43	56 21 77	87 24 111/11	11 4 15	37+8 45	71+81 89	164+22 188/19	$\frac{166}{8}$	
	1943	10 25 35	24 26 50	47 28 75	.. ..	28 6 34	37 11 48	68 17 85	..		$\frac{160}{8}$
7. Borax	1942	35 15 50	59 15 74	72 16 88	134 19 153/15	17 22 39	40* 14 54	92* 18 110	106* 20 126/12	$\frac{198}{10}$	
	1943	14 9 23	31 15 46	53 17 70	.. ..	13 7 20	24 7 31	44 15 59	..		$\frac{129}{7}$
Unbarked logs 1. Untreated Control	1942	30 17 47	130 35 165	378 54 432	486 58 544/54	41 11 52	124 22 146	269 38 307	373 60 433/43	$\frac{737}{37}$	
	1943	37 2 39	41 6 47	227 6 233	.. ..	25 2 27	27 4 31	520 25 545	..		$\frac{778}{39}$
2. Cowdung	1942	26 3 29	95 62 157	443 90 533	443 98 541/54	48 9 57	126 22 146	204 28 232	268 47 315/31	$\frac{765}{38}$	
	1943	17 1 18	55 2 57	562 15 577	.. ..	43 0 43	73 5 78	246 33 279	..		$\frac{856}{43}$
3. Lime Wash	1942	35 4 39	166 41 207	295 66 361	453 73 526/52	60 5 65	85 12 97	120 30 150	201 40 241/24	$\frac{511}{25}$	
	1943	10 3 13	45 3 48	452 58 500	.. ..	13 0 13	41 2 43	346 34 380	..		$\frac{880}{44}$
4. Crude Oil/ Thin Tar	1942	29 1 30	91 31 122	242 40 282	320 45 365/37	39 0 39	75 20 95	136 27 163	222 38 260/26	$\frac{445}{22}$	
	1943	2 0 2	19 0 19	83 14 107	.. ..	16 0 16	40 1 41	182 40 222	..		$\frac{329}{16}$
5. P.dichloro-benzene in Crude Oil	1942	23 3 26	153 34 187	398 51 449	570 59 629/63	62 1 63	71 10 81	94 23 177	145 37 182/18	$\frac{566}{28}$	

Note:—*1942 experiments counts taken from one replication only and doubled for comparability—logs lost by sudden and short-lived flood.

+One ½ log lost through flood and counts adjusted for comparability.

P="Pin hole" bores.

S="Shot hole" bores.

Denominators give number of bores per 6 in. square surface.

It will be seen from these results that :—

(*a*) Thin tar has been the only passingly deterrent of all treatments tried in all its replications and both repetitions and that, only in the case of barked logs. In the case of logs with bark intact this treatment difference though still evident is much less pronounced and the incidence of borers not so markedly less than in other treatments.

(*b*) That in all cases irrespective of treatments the number of bores on *unbarked* logs have been several times (about 4 times in 3 months) more than in the corresponding *barked* logs—*vide Table II* on page 113.

(*c*) Infestation by borers has been greater on the underside of the logs in the case of all logs, whether stacked high or low and irrespective of treatment. This is probably due to the simple reason of the drying and heating effects of the sun on the upper surfaces.

(*d*) Stacking logs raised 2 ft. on trestles or only 6 in. on pole runners did not make any difference to the intensity of borer infestation. There is no advantage to be gained therefore by stacking the logs raised well above ground as has been tried.

At the conclusion of the observations above, *i.e.*, after a period of six months from initial treatment all the logs of the 1942 and 1943 experiments were sawn to 1 in. and ½ in. planks respectively. Approximately 200 planks from each lot of trials were obtained and carefully examined one by one—for stain, decay and borers. The following is a synopsis of results :

i. Fungal decay is by far the most serious defect at this stage of storage under field conditions no matter what form of surface treatment with or without bark, or form of stacking is followed. This decay had rendered all logs useless for any purpose whatsoever inside of 6 months.

ii. Had decay taken no part in the deterioration of the logs degrade caused by borers alone on *barked* logs, irrespective of treatments, would not have been any worse than could be characterised by the trade term "prime wormy" except perhaps for the outermost planks.

iii. Incidence of all types of coleopterous borers was definitely higher on logs left with bark intact than on logs with bark removed. The tissues between the outermost corky layer and the wood in the former had been turned into a compact hard mass of frass leaving only a thin outer covering to disguise the rot within.

iv. Large longicorn bores were entirely restricted to planks from logs with bark intact.

v. No appreciable differences correlated with surface treatments of the logs were apparent. Though planks from sections of barked logs coated with thin tar shewed less bores than planks from logs of other treatments, the fungal decay was as much or more.

vi. All planks from logs kept immersed, for 6 months in a stream before sawing, were found clean and sound free from any bores or fungal stains or decay.

Logs Immersed in Water:

It was attempted in the 1943 set of experiments to keep half the number of logs used completely submerged by weighting them down with large stones and allowing the rest to float. Within a period of 6 months all but one log of those left floating sank by themselves. To test susceptibility to borer after varying periods of immersion 2 ft. lengths were cut and removed from 2 logs at a time and exposed to infestation stacked in the open on 6 in. diameter runners. Counts of bores were taken at monthly intervals from four-2 in. wide diagonally opposite strips running the length of each section. *Table III* on page 113 gives a summary of counts for the 2 years, 1942 and 1943. It is found that whilst remaining free of borer for as long as logs are kept in water, logs kept submerged up to 6 months in a running stream were still subject to borer infestation when taken out of the water.

These results received further confirmation from 52 planks (6 in. x ½ in. x 10 ft.) sawn from 2 logs (of the 1943 set of experiments) that had been in water for a period of 6 months. These were divided at random to 6 lots of planks and treated with the same preservative solutions as in the case of the other experiments with sawn planks of that year. Unfortunately there was a delay of 6 to 7 days between the dates of sawing and treatments. This was sufficient for infestation and all surface treatments failed to prevent action of the borers. All planks treated and untreated

stacked for air seasoning with 1 in. and 2 in. stickers were infested.

Experiments with Sawn Planks—1942

Three major sets of experiments have been carried out. In the first set of 1942, 36 planks (6 in. x 1 in. x 10 ft.) were used, 6 for each of the following treatments, *immediately* after sawing. After treatment the planks were stacked for air seasoning under cover with 1 in. stickers.

i. Untreated control.

ii. One brush coat of *lime wash* made up as for ordinary whitewashing using fish glue as sizing.

TABLE II

Treatment		Logsraised 2 feet off ground							Logs raised 6 in. off ground								
		1st month		2nd month		3rd month		Total	1st month		2nd month		3rd month		Total	Grand Total	
		P	S	P	S	P	S	P+S	P	S	P	S	P	S	P+S	P	S
Barked	1942	132	59	239	80	425	105	530	102	45	287	49	564	77	641	989	182
	1943	89	60	146	76	293	98	391	111	31	165	40	303	70	373	596	168
Unbarked	1942	143	28	635	203	1756	301	2057	250	26	481	86	923	146	1069	3679	447
	1943	66	6	160	11	1334	83	1417	97	2	181	12	1294	132	1426	2628	215
Totals 1942+43		430	153	1180	370	3808	587	4395	559	104	1114	187	3084	425	3509	6892	1012

TABLE III—SUMMARY OF COUNTS OF BORES ON SECTIONS TAKEN FROM LOGS KEPT IMMERSED IN WATER AND EXPOSED TO INFESTATION.

Treatment		1st month	2nd month	3rd month	4th month	5th month	6th month	7th month
		P S	P S	P S	P S	P S	P S	P S
Immersion 1 month :								
Barked—	1942	8 0	8 0	15 0	16 0	..	..	..
		8	8	15	16			
	1943	15 0	70 0	..	..	..	76 2	83 3
		15	70				78	86
Unbarked—	1942	14 0	48 0	86 4	97 7	..	..	..
		14	48	90	104			
	1943	51 0	122 0	..	..	..	137 17	154 24
		51	122				154	178
Immersion 2 months:								
Barked—	1942	19 0	28 0	33 1	..	..	..	..
		19	28	34				
	1943	30 0	..	..	..	37 1	40 1	..
		30				38	41	
Unbarked—	1942	24 1	70 1	113 29	..	..	..	..
		25	71	42				
	1943	77 0	..	..	..	94 12	102 20	..
		77				106	122	
Immersion 3 months:								
Barked—	1942	20 0	23 1	..	..	..	..	..
		20	24					
	1943	..	52 0	74 0	..	..	..	..
			52	74				
Unbarked—	1942	99 1	150 3	..	..	..	..	..
		100	153					
	1943	..	159 5	235 17	..	..	..	..
			164	252				
Immersion 4 months:								
Barked—	1942	30 0	..	..	..	..	..	..
		30						
	1943	..	..	..	..	..	..	..
Unbarked—	1942	98 1	..	..	..	..	..	..
		99						
	1943	..	..	..	..	..	..	..

iii. One liberal brush coat of a boiling *hot* 10 *per cent aqueous solution of borax*.

iv. One liberal brush coat of a boiling hot decoction of chopped roots of *Derris uliginosa* Benth.

v. One light brush coat of a cold aqueous solution of Ascu ($\frac{1}{4}$ lb. to the gallon of water).

vi. One light brush coat of a cold aqueous 5 *per cent* solution of Sodium silico-fluoride.

Note:—The decoction of the roots of *Derris uliginosa* was prepared by boiling (in a 4 gallon drum tightly packed with chopped roots and filled with water) for a period of 6 hours.

Experiments with Sawn Planks—1943

In the 1943 set of experiments 72 planks 6 in. x $\frac{1}{2}$ in. x 10 ft. *i.e.* 12 planks per treatment, half stacked with 1 in. and half with 2 in. stickers for air seasoning, were used. The preservatives were the same as in 1942 except that:—

(*a*) a cold water extract of chopped roots of Derris prepared by letting the root chips steep in the same drum for 48 hours before use;

(*b*) treatments (*iii*) to (*vi*) were varied to steeping each plank for 1 minute in a trough filled with the preservatives mentioned. This was found to be more satisfactory and much quicker than brush coating except in the case of whitewashing which in this instance was prepared using starch paste as a sizing.

Experiments with Sawn Planks—1945

The last set of trials of 1945 were carried out, with 70 planks 6 in. x $\frac{1}{2}$ in. x 10 ft. using 10 planks per treatment, immediately after sawing and stacked for air seasoning using 2 in. stickers. The same forms of treatments as in 1943 were employed omitting treatments (*ii*) and (*iv*) *i.e.* Derris root decoction and lime wash and adding:—

vii. Immersion in a 1 per cent. hot water suspension of the Imperial Chemical Industries *Gammexane* preparation *P. C. 1147*.

viii. Immersion in a 2 per cent. solution of the *Gammexane* preparation *P. C. 982* in petrol.

ix. Immersion in a 1 per cent. solution of D. D. T. in petrol.

Counts of bores which were almost entirely of pinhole size were taken at weekly intervals for the first month and at monthly intervals thereafter. The summary of the counts taken at the end of the 1st, 3rd, 6th and 8th months for the 3 sets of trials are given in *Table IV*, on page 115. The counts for the 1st and 3rd month of the 1942 set of experiments were from 2 in. wide indicator lines run centrally on the two sides of each plank. As the numbers of bores to be counted were small those on the whole of the sides of each were taken thereafter and in the later experiments.

The planks were fully air seasoned, at the end of 5 to 6 months for 1 in. planks and 3 to 4 months for $\frac{1}{2}$ in. planks as determined by constant weight at two consecutive monthly weighments. Only untreated controls and planks of treatments (*iv*) *and* (*vi*) were slightly blued and all other planks were perfectly clean. There was no appreciable degrade from end splitting and no differences were apparent in this respect between seasoning with 2 in. stickers as compared with the use of 1 in. stickers.

All forms of treatment except treatment (*v*) gave very satisfactory immunity from borers and stain with prompt air seasoning under cover. In the case of treatment (*iv*) the incidence of borers was greatly enhanced and actually about 10 times as bad as in the untreated controls in the 1942 set of experiments. In the 1943 experiments however very fair protection was obtained for the first 8 months. This difference in the results is probably due to the Rotenone, the active insecticidal alkaloid of the Derris, being thermolabile and destroyed by boiling. It would appear also that the insecticidal effects even of a cold extract wears off after a few months. The Derris-root decoction from either method of preparation is not satisfactory.

All other forms of treatment *viz*:—Lime wash, Borax, Ascu, Sodium silico-fluoride, Gammexane (P.C. 1147 and P.C. 982) and D.D.T. were all extremely effective in preventing borers.

TABLE IV—SUMMARY OF COUNTS OF BORES ON SAWN PLANKS
(6-planks 10ft.x 6in.x 1in. or ½ in. per treatment).

• Treatment		Counts of Bores: 1st. mth. 1″	1st. mth. 2″	3rd. mth. 1″	3rd. mth. 2″	6th. mth. Stacked 1″ apart	6th. mth. Stacked 2″ apart	8th mths. 1″	8th mths. 2″	Per 6″ square for last count	Remarks
I. Untreated Control	1942	April 3	–	July 3	–	October 52	–	–	–	.2	1942—Planks 10′x 16″x1″. 1943 & 1945 „ 10′x 6″x½″. 1942—Derris Decoction boiled extract.
	1943	May 4	1	August 18	16	825	883	2303	1633	10/7	1942—Derris decoction cold water extract.
	1945	Sept. –	0	Nov. –	0	–	112	–	–	.5	1942—6 month.
II. Lime Wash	1942	4	–	4	–	10	–	–	–	.04	86/470 = Heart/Sap infestation.
	1943	0	0	0	0	0	0	1	0	.00	
	1945	–	0	–	0	–	0	–	–	.00	
III. Borax	1942	2	–	9	–	12	–	–	–	.01	32/51 = Heart/Sap without Derris decoction. (All pin holes except 4 shot holes).
	1943	2	0	7*	0	7	0	1*	0	.00*	
	1945	–	0	0	0	–	0	–	0	.00	
IV. Derris Decoction	1942	5	–	18	–	463	–	–	–	.2	*Spots mistaken for bores in 3rd. month.
	1943	0	0	0	0	44	0	82	0	.4	
V. Ascu	1942	0	–	0	–	2	–	–	–	.01	
	1943	0	4	0	9*	0	9	5	5*	.00	
	1945	–	0	0	0	–	0	–	0	.00	
VI. Sodium Silico-fluoride	1942	3	–	7	–	7	–	–	–	.01	
	1943	2	0	5	1*	5	1	5	0	.00*	
	1945	–	0	0	0	–	0	–	0	.00	
VII. P.C. 1147/666.	1945	–	0	–	0	–	0	–	0	.00	
VIII. P.C. 982/666.	1945	–	0	–	0	–	0	–	0	.00	
IX. D.D.T.	1945	–	0	–	0	–	0	–	0	.00	

TABLE V

Treatment		Counts of Bores months from initial treatment: 14 months	15 months	18 months	20 months	Remarks
1. Control (Untreated)	Sprayed	321	486	535	1079	4 planks
	Air dry	70	128	148	228	2 planks
2. Lime Wash	Sprayed	0	0	0	3	
	Air dry	0	0	0	0	
3. Borax	Sprayed	0	0	0	3	
	Air dry	0	0	0	0	
4. Ascu	Sprayed	0	0	0	50	
	Air dry	0	0	0	40	
5. Sodium—silico—fluoride	Sprayed	0	0	3	6	
	Air dry	0	1	1	14	

TABLE VI—SUMMARY OF COUNTS OF BORES ON 10 TEA CHESTS IN STORAGE AND TRANSPORT FOR A PERIOD OF ONE YEAR.

Treatment	Box A after 4 mths. use	Box A after 12 mths. use	Box B after 4 mths. use	Box B after 12 mths. use	Mileage (4 journeys per Box). Train	Lorry	Other Means	Storage (packed)	Remarks
1. Lime Wash	39	212	124	947	755	464	6	7½ mths.	Given to the Tea Controller
2. Borax (Hot)	0	0	0	0	790	207½	3½	6½ mths.	13 mths. after
3. Derris (Cold extract)	67	169	149	350	537	271½	4½	6½ mths.	initial treatment. Last
4. Ascu	54	304	20	163	778	183½	4 mls.	6½ mths.	counts 2 yrs.
5. Sodium-silico-fluoride	0	201	0	185	733	246	8mls.	6½ mths.	3 mths. after initial treat-

Owing to the absolute absence or insignificant number of bores found with the use of these insecticides it is not possible to distinguish between their relative values. Which of them should be employed for the treatment of *malaboda* planks will have to be determined by the subsequent uses those planks are to be put *e.g.* for the purposes of making chests for food products or tea, *Borax* and *Sodium silico-flucride* would be the obvious choice. If for weather or ceiling boards all other forms of treatment may also be employed—for internal panelling or partitions it would be advisable not to use *Ascu.*

It is difficult in most cases to distinguish sapwood from heartwood from colour differences alone. From general observations however the sapwood, as might be expected, is more prone to borers than the heartwood. The central pith is even more attractive to borers than the sapwood and heaviest infestations have been observed here. Owing to the corky non-absorbtive character of the pith the treatment with insecticidal solutions are less effective here than elsewhere. It is best for this reason carefully to exclude the central pith in sawing.

Treated Planks Subject to Periodic Wetting

To determine whether the resistance to borers of treated planks would be maintained under periodic wetting or light washing the planks of the 1942 set of experiments were sawn across into halves (5ft. x 6in. x 1in). 4 of each of the 6 planks of each treatment were set up edgewise on the ground about 2 in. apart and thoroughly sprayed with 2 watering cans full of 3 gallon capacity. The planks were then restacked as for air seasoning with 1 in. stickers. This treatment was repeated thrice at fortnightly intervals. The other 2 planks of each experimental lot were left stacked similarly under cover. Whilst spraying periodically did very appreciably increase incidence of borers on the untreated planks over and above those kept air dry, treated planks were not so affected—vide summary of results in Table V on page. 115. Only pinhole and no shothole borers appeared.

Treated Planks Converted and Used as Tea Chests

The planks from the 1943 set of trials were converted into ten ½ size tea chests—2 boxes from each treatment set of planks—13 months after initial treatment. The planks at this stage were yet clean sound and virtually free of any borers. They were lightly planed and smoothed in the process of conversion. By the kind collaboration of the Tea Commissioner these boxes were filled with tea and subjected to alternate storage and transport by rail, lorry and carts over a period of a whole year. Each box made four return trips from Colombo to Galle, Jaffna, Badulla, Nuwara Eliya and other intermediate stations on shorter journeys. The boxes were examined at 4 months after use and on final return by the Tea Commissioner after 12 months use. Counts of bores on the outer surfaces recorded. *Table VI* on page 115 gives a summary of the counts of bores on each of the boxes, the total mileage by various means and periods of storage in between journeys.

Results

Both boxes prepared from planks treated with a hot 10 per cent solution of borax and one box made from planks treated with a 5 per cent solution of sodium silico-fluoride were completely free of borers. The failure of the latter treatments and "Ascu" to give continued resistance to infestation as the borax had done is due no doubt to lack of penetration by cold solutions as compared with the hot solution of borax used and the removal of the originally treated surfaces by planing in the course of the construction of the boxes. It is probable that *borax, Ascu* and *sodium silico-fluoride* solutions would also have been equally effective as the first if all had been used hot or if the shooks were re-treated after fashioning. The insecticidal properties of the *Derris* extract is lost with keeping and this would not in any case for that reason have sufficed. In the case of lime wash the effect appears to be solely a matter of a physical barrier against boring and ovipositing by beetles responsible caused by the layer of lime.

Further Tests with Treated Planks of 1945

In May, 1946 one half of each treatment set of planks of the 1945 experiments were nailed up on posts outdoors in the central timber depot yard, Colombo. The other half of each set were nailed up as screens under cover in the open sheds at the depot. This was 10 months after initial treatments. All planks were sound clean and free

from any stains or decay. The "control" planks were lightly infested with borers but all treated planks were entirely free of them. The observations during the past 4 months indicate that planks outdoor, exposed to sun and rain, remain free of borers including the untreated controls whilst under cover borers have persisted on the latter. This is a rather unexpected result brought about by the drying and heating action of the sun. It remains to be seen whether fungal decay may not upset these results later on.

Sub-Crown Girdling before Felling and Conversion

There is reason to believe that the 'Powder Post' and 'Ambrosia' beetles we have to contend with in the case of *malaboda*, depend for their nutrition on the starch and sugar contents of the wood*. Another line of investigation followed therefore was designed to make the trees utilise all their available food resources before felling. 5 trees of approximately equal girth and height standing not far from one another in the Indikade forest reserve were chosen. The average girth at breast height of these trees was 4 ft. and the average bole length 40 ft. A deep girdle of 6 ins. width about ½ in. into the wood was cut immediately below the main crown of each tree and any live branch found below this was cut down so that the translocation of prepared food substances from the crown to bole and roots was prevented. Observations were kept monthly on the reactions of the crowns of these trees to the subcrown girdling. The results were, as summarised in Table VII below, where the abbreviations UA=Crown unaffected; SA=Crown slightly affected *i.e.*, less than half leafless; BA=Crown badly affected *i.e.*, Crown more than ½dead and D=Dead *i.e.*, Crown completely leafless.

TABLE VII—CROWN REACTIONS TO SUB-CROWN GIRDLING

Tree No.	Month of observation.												
	1st 30-4-44.	2nd 30-5-44.	3rd 27-6-44.	4th 29-7-44.	5th 27-8-44.	6th 25-9-44.	7th 25-10-44.	8th 30-11-44.	9th 19-12-44.	10th 23-1-45.	11th 15-2-25.	12th	Remarks
1	U.A.	U.A.	U.A.	U.A.	S.A.	B.A.	D.						Felled 25-10-54
2	U.A.	U.A.	U.A.	U.A.	S.A.	S.A.	S.A.	S.R.	S.A.	S.A.	S.A.	S.A.	„ 6-10-45
3	U.A.	S.A.	U.A.	U.A.	S.A.	S.A.	B.A.	B.A.	D.				„ 19-12-44
4	U.A.	U.A.	U.A.	U.A.	S.A.	S.A.	S.A.	S.A.	S.R.	S.A.	S.A.	S.A.	
5	U.A.	U.A.	U.A.	U.A.	S.A.	S.A.	S.A.	S.A.	S.R.	S.A.	B.A.	D.	„ 25-2-43

Base Girdling Super-imposed

Trees numbered 1, 3, 5 and 2 were felled 7, 9, 11 and 19 months after initial crown girdling. The crowns of these trees were completely dead in the month in which they were felled. The crowns of 3 trees were only slightly affected 9 months after initial subcrowm girdling. The girdles were still clear and free of any bridging by callus tissue. The only apparent reason for continued life of the crowns was the possibility of subterranean root-grafts with neighbouring trees which fed and kept the roots and bole of the girdled trees sufficiently alive to keep the isolated crowns of these trees supplied. These trees were therefore deep base girdled as well, trees 2, 5 and 4 in the 9th, 10th and 12th month respectively after initial girdling.

Borer Infestation on Planks from Pre-Girdled Trees

The boles of each tree were logged into 10 ft. lengths taken from the top and butt ends first and the remaining logs from intervening section. These were sawn separately into ½ in. planks and stacked for air seasoning under cover using 1 in. stickers. All planks from 3 trees felled first became heavily infested with borers in due course without any apparent differences relative to their positions in the trunks of the trees. In the case of the last tree, planks from the top and log were appreciably less affected by borers than those of the other sections of the trunks. No borer infestations have appeared on any of the trees before felling nor are there any now on the last tree still standing—2½ years after first sub-crown girdling. Investigations on this line of approach to the understanding and control of borer infestation of *Malaboda* are proceeding.

*In the case of *Ambrosia* beetles the association with starch and sugar would be indirect since their larvae

POST-WAR SILVICULTURAL RESEARCH IN BIHAR.*

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We have drawn up an outline of research work in consultation with the central silviculturist which we propose to carry out and will cover briefly the following schedule:—

I (*a*) to work out the extent, nature and intensity of cultural operations necessary in creeper and climber infested regeneration areas of the *sal*, C. W. C. in Singhbhum in order to establish the new crops in the shortest and most economical time.

(*b*) to ascertain in typical dry hill coppice the extent to which stump mortality is occuring under current management.

(*c*) to examine if, in typical Palamau/Porahat forests, *salia* bamboo can be managed with an overwood of high and coppice forests for a sustained yield of both.

(*d*) to determine the extent to which new recruitment occurs of *sal* (*Shorea robusta*) under coppice with standards management in the Palamau division.

(*e*) to determine whether adequate *sal* recruitment and development is taking place in Palamau/Porahat divisions, where there is an intimate admixture of *salia* bamboo with *sal*.

(*f*) in the damp valleys of Singhbhum with limited *sal* present to determine if its regeneration, natural or artificial, can be economically established and developed; and with little or no *sal* present to determine whether such species as *simal* (*Bombax malabaricum*), *burkund* (*Hymenodictyon excelsum*) and *cadamb* (*Anthocephalus cadamba*) etc. available in these localities, can be economically reproduced and extended, or introduced where absent.

(*g*) to ascertain the possibilities of economically improving the stocking of dry hill areas with *sal* or other marketable species where such restocking is at present difficult.

II. To establish one, and in some cases two preservation-cum-ecological strips or areas in all divisions on the basis of technique worked out with the botanist, forest research institute.

III. The establishment of some fifty more sample or statistical plots to cover a large range of qualities and common species (including S. T. I. plots) and with variations for geological formation aspect and form of management.

IV. The laying out of two composite *salia* bamboo cutting-cycle plots in Palamau and Porahat divisions, in relation to recruitment and development.

V. Outturn or yield measurements for QI to QIV *sal* high forest as well as the A and B classes of *sal* coppice.

VI. A biennial strip or lot enumeration of fungal incidence in areas of *sal* under exploitation as coppice or high forest in relation to geological formation, stump diameter, aspect and gradient.

VII. A series of experiments dealing with land reclamation and reforesting in localities that have become denuded of forest cover and eroded in conjunction with grass ecological liner strips and the Gorrie apparatus for testing run-off lossess.

VIII. Recreation of a central nursery and experimental station of sizes and equipment that will allow for seed germination and establishment tests, planting technique tests; and tests for, and under, the proper development of young plantations of the more common species exploited in the circle. This station will also comprise a small botanical garden for likely local and exotic plants. It might be mentioned that the old forest nursery established some years ago had to be given up as the land was required by the Military.

IX. The selection, laying out and establishment of 27 *sal* thinning plots in typical Singhbhum *sal* of the C. W. C. in accordance with the technique and provisions worked out with the silviculturist, forest research institute.

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*Paper read at the 7th Silvicultural Conference (1946), Dehra Dun, on item 1—The organization of post war silvicultural research.

It was perhaps not necessary to give the above details in this short paper but I have done so merely to indicate the nature of problems we have to tackle in Bihar and we will only be too glad to cooperate with other provinces having similar problems in carrying out this work. It is suggested that all the provinces should circulate their research programmes so that the provincial silviculturists may know what is being done in other provinces and those interested in similar problems may contact one another with a view to co-operate in solving their common problems.

(c) It will, in my opinion, be a good idea to alter the central silviculturist's porgramme from a three years basis to that of five years.

(d) In order to carry out the proposed programme of work it is necessary to have adequate staff. At present there is only one officer who combines the duties of the silviculturist and the working plans officer. The proposal to have a separate silviculturist with adequate subordinate staff is now under consideration.

(e) There can be no two opinions regarding the necessity of special training for silviculturists and silvicultural rangers at Dehra Dun. In order to maintain continuity in research work it is important that the transfer of the staff employed on this work should be restricted as far as possible. It is suggested that a minimum period of five years may be fixed for keeping the silviculturists in their posts.

GROW MORE TREES, THE NEED OF THE DAY

For fine houses and fine cities
And the finest of furniture;
Fine ships to sail the seas,
And the implements of agriculture;
Grow more trees, the need of the day.

Ruthlessely have they been felled,
And remaining grass been grazed.
Land once smiling, now is waste.
To stop that land from being erased,
Grow more trees, the need of the day.

All the sand from barren hills,
And that from the Thar desert;
Is filling in, in our precious fields.
To check this evil and the land inert;
Grow more trees, the need of the day.

Fine mornings are dull and mallow
With ghostly stretches of land;
'thout life and signs of sparrow.
To have the peacocks dance and play;
Grow more trees, the need of the day.

The clouds* come from far to shed,
Their rain on lively land and trees;
But they float away when the ground is dead.
To have more rain, grain and hay;
Grow more trees, the need of the day.

All the heavy rain would pour,
To sink in fields and give us yield;
But lo! All is wasted and floods are caused.
Then why not take steps today;
Grow more trees, the need of the day.

Let no waste land be-by farm
Roads, garden nooks and ponds,
Without trees that keep us warm
To have more fuel and beautiful surround,
Grow more trees, the need of the day.

Trees are friends to us as they bring
Rain to us and protect the fields;
They are wealth to us and springs
Of life that keep us alive and gay;
Grow more trees, the need of the day.

S. D. N. TIWARI.

*The idea that there is more rainfall due to forests has been expressed.

EFFECT OF DIAMETER OF TEAK STUMP ON SURVIVAL AND HEIGHT GROWTH

(HOSHANGABAD DIVISION CENTRAL PROVINCES, BORI SPECIAL TEAK WORKING CIRCLE.)

The Central Silviculturist has sent us the following further account of the experiments started in 1943 and 1944 in the Bori forests by the divisional forest officer, Hoshangabad on the effect of the diameter of teak stumps on survival percentage and height growth.

The experiments are of interest in that they confirm the results of the original experiments in Madras and also show that even after three growing seasons differences are still significant.

The results are very striking and very important in the early competition of a plantation against weeds.

An account of these experiments appeared at pages 329—331 of the *Indian Forester* **of October, 1945.**—*Hon. Ed.*

This note brings the results up to the 1945 measurements, which are given below, together with those of the previous years.

1943 experiment

Treatment	Size of stump in inches	Survival percentage			Mean height in inches.		
		1943	1944	1945	1943	1944	1945
A ..	0.3—0.4 ..	79	76	79	5.2	29.0	87.3
B ..	0.4—0.5 ..	86	82	79	7.5	38.4	77.4
C ..	0.5—0.6 ..	84	81	83	9.5	45.7	85.0
D ..	0.6 0.7 ..	93	89	91	11.1	50.3	93.4
E ..	0.7—0.8 ..	95	91	87	12.5	50.2	103.1

The analysis of variance as regards height growth in 1945 is as follows:—

Variation due to	Degrees of freedom	Sum of squares	Variance	F
Replications ..	4	1819.89	454.973	
Treatments ..	4	1851.22	462.805	4.248
Error ..	16	1743.35	108.959	

F at the 5 percent level is 3.01. The treatments are thus significant.

The critical value at the 5 & 1 percent levels respectively is a difference of 14 inches and 19 inches in heights. The 0.7 to 0.8 inch diam. class of stump is therefore still superior to A, B & C.

1944 experiment

Treatment	Size of stump in inches	Survival percentage		Average height in ins.	
		1944	1945	1944	1945
A ..	0.3—0.4 ..	50	Figures not available	6.4	42.7
B ..	0.4—0.5 ..	76		7.2	63.9
C ..	0.5—0.6 ..	91		10.2	69.5
D ..	0.6—0.7 ..	90		12.2	65.3
E ..	0.7—0.8 ..	88		13.2	70.8

The analysis of variance as regards height growth in 1945 is as follows:—

* Variation due to	Degrees of freedom	Sum of squares	Variance	F
Replications ..	3	437.92	145.973	
Treatments ..	4	2,081.66	520.415	44.39
Error ..	12	1,922.17	118.514	

F at the 5 per cent. level is 3.26. The treatments are thus significant. Here, however only A is significantly inferior to the rest which *inter se* are not statistically different at the end of the second growing season.

Discussion

These results confirm the conclusion arrived at before that it is not worthwhile to use stumps of diameters from 0.3 to 4 inches.

PANVIN BURNING IN SOME OF THE UPPER SIMLA HILL STATES

By Pritam Das

(*Wazir and Forest Officer, Rawingarh State, Simla Hills.*)

Panvin burning is a local term used for the annual burning of pastures and *dehat* (village) forests in some of the upper Simla hill states.

When I first took over as a *wazir* of Rawingarh, on the 15th January 1941, I saw to my great surprise, all the surrounding *dehat* forests of the state which contained old stems of pure *Kail* (*Pinus excelsa*) and the pastures in Keonthal state which overlooked my quarter, black burnt. Being originally a forest man and unaccustomed to see such promiscuous burning of the forests in my native state, Balson, the dark view around me presented a dreadful picture to me and the enigma attracted my curious and keen attention to know the real cause of the harmful practice the result of which *prima facie* seemed disastrous.

On enquiries from the forest staff I was told that the people have rights to burn their pastures annually and the surrounding *dehat* forests were also covered by such burning. By such burning growth of green grass was accelerated in March and April when there was scarcity of grass for cattle, sheep and goats in these places. But being an agriculturist, rather than a ploughman myself and having hundreds of cattle at my home, the argument did not convince me to my entire satisfaction. Later on the charge of the state forests was also handed over to me and thus I became in double contact with the people. On further enquiries I found that the people had a sort of mania since the very old times to burn forests and pastures even if they got nc apparent benefit by such burning. While going through the forests I found all the burnt *dehat* forests thickly covered with bracken fern which in winter was transformed in a thick layer of humus, took a long time to decay and thus prevented the seed from reaching the soil. If somehow or other stray seeds reached soil and germinated the sapling could not escape from burning with the result that there was no regeneration worth the name of any species in the *dehat* forests. As for pastures, the people even burn those hillsides which are inaccessible to the cattle either due to their long distance from the villages or are of steep nature. The results of such indiscriminate burning can better be imagined than described and suffice it to say that the practice is barbarous and its effects are disastrous.

Being inspired with forest feelings I could not remain a silent observer of the harmful practice which obviously seemed to be based on a foolish custom. I resolved to do away with the practice and selected distant areas first for prohibition of burning. There was some opposition on the part of the local people who felt the prohibitory orders quite new and unusual; but they were placated soon. I pursued the policy very firmly and prohibited all the other areas by and by, with the result that burning of *dehat* forests in the state has been completely stopped and state assets worth lacs of rupees have been saved from destruction without causing any harm or trouble to the state subjects. Now the next but equally important step will be to stop the burning of the barren hillsides which I believe will be done similarly within a few years to come.

What is required to stop this barbarous and widely affecting practice is to select the rather distant areas of the *dehat* forest or the barren hillsides, as the case may be, and prohibit them strictly for burning. When success is achieved in saving the distant areas from burning the prohibition policy should be extended, by and by, to the nearer areas until every barren or wooded area is prohibited for burning. There is bound to be vehement opposition on the part of the local people but one should not become disappointed and should face such opposition boldly and pursue the path steadily. Executive aid however is indispensable to translate the scheme into action otherwise all the efforts to achieve the object are bound to prove abortive.

EXTRACTS

THE VEGETATION OF SOME HILLSIDES IN UGANDA.

By A. S. Thomas

(Department of Agriculture, Uganda)

The Influence of Man on Soils in Uganda.

The catenas at Bujumba and Nansagazi, the most southerly of those described, are situated on rocks of the Karagwe Ankolean system, which is composed largely of phyllites and quartzites. The other four catenas are situated on the Basement Complex of schists, gneisses and crystalline quartzites; a gneiss is exposed on the hilltop at Kakinze and a ridge of quartzite at Kawanda.

There are no volcanic or basic rocks in these catenas, yet there are great differences between the soils found on them. In general, the soils to the south seem to be more acid than those to the north; as there is a heavier rainfall in the south, it might be expected that the soils there would be more leached and poorer in bases than those of the drier areas in the north. But, even in any one catena, there are great differences between the soils in different zones—

in reaction, in texture and in colour. As chemical analyses are available of the Bukalasa catena (Martin and Griffith, 1940) which resembles that at Kawanda, one or two points which these catenas have in common may be mentioned.

One of the most interesting features of both catenas is the difference in the colours of the soils—those of the hilltops are grey, those of the hillsides are red brown, and those of the valleys are grey. It is a common practice to speak of all red or red-brown soils in the tropics as being laterized but, as Martin and Griffith point out, it is better to speak of the red soils at Bukalasa as 'red earths' for they have a silica/alumina ratio of about 2.0 and are on the borderline of the true laterites.

The classical work of Harrison (1933) in British Guiana showed that under equatorial conditions, with high temperatures and heavy rainfall, it is to be expected that basic rocks will weather to form laterite and acid rocks will weather to form kaolin. Kaolin appears to be abundant in the grey soils of the valleys at Bukalasa and Kawanda and also in the grey soils of the hilltops; yet the soils on the slopes between are red, and it would be difficult to account for these differences as due to ordinary soil-forming processes.

Native tradition states that the reddening of the soil is due to lengthy human settlement. This is the most feasible explanation of the change in colour, for it seems impossible otherwise to account for the occurrence of patches of reddish soils in close proximity to grey or black soils, sometimes on the same contour of the hill. Such occurrences may be seen not only in the part of Buganda described in this paper but in many other areas of the Uganda Protectorate, in places which differ greatly in their rocks and climates.

Human settlement does undoubtedly lead to a local concentration of bases in the soil; comparisons between samples 1 and 2 at Bujumba and between samples 2 and 3 at Kakinze show that there is a much greater amount of bases in the soil near the houses than in the soil at a little distance from them. This concentration of bases is a matter of some economic importance; for example tea, a calcifuge, will not grow on old house sites; and it is a persistent effect, for the failure of tea in patches has shown the existence of house sites even in the Kijura area (in the west of Uganda) which is known to have been uninhabited for over forty years.

It is quite probable that the reddening of soil may be connected with the addition of bases. Harrison (loc. cit.) showed that when acid rocks weathered, there is a tendency for the iron to be leached out, leaving a light-coloured soil rich in kaolin; but that when basic rocks are decomposed the alkaline solution tends to remove the silica, leaving the iron and alumina, and a reddish soil is formed. Similarly, it is possible that the more alkaline soil solution, induced by the addition of ashes, of animal and vegetable refuse to the land near houses, may lead to a leaching of silica and an accumulation of iron, producing the 'red earths' so abundant in Uganda. The mounds of many species of termites are redder than the soils or the subsoils on which they are built; as in the case of human settlements, so also in the case of these mounds, it is possible that the change in the colour of the soil may be connected with the local concentration of bases by biological activity.

Whatever may the chemical processes involved in the formation of 'red earths' in Uganda, there is much evidence of the physical processes—that often they are built-up soils. Much attention has been paid to erosion of tropical soils, but little to the processes by which they are built up. Soil erosion does occur in Uganda, but is much less evident in Buganda than in the Eastern Province, where the soils are more sandy and the dry seasons more marked. The more spectacular examples of soil erosion in the tropics are not usually to be seen in the areas of heavy, well distributed rainfall, where a cover of vegetation is maintained over the soil; but they are to be seen in places where the total annual rainfall is less and where the dry seasons are so long that most of the plants are grazed or burnt away, exposing the bare soil to the full force of the rains when they break.

Even, though there may be little erosion of the soil surface in Buganda, it seems that there is a definite movement of the soil downhill, a movement which gives rise to the popular superstition that the stones on the hilltops grow in size. It is probable that this movement is due to 'soil creep'—the slow movement of the particles underground when they are wet—for, while the construction of narrow-base contour bunds in coffee plots at

the Kawanda Research Station has effectively prevented the movement of water or soil on the surface, yet it has led to a rapid terracing of the land.

The diagram of the catena at Kawanda indicates that there has been a movement of soil from the hilltop. The level of the land falls steeply down to the area which is cultivated; it falls more slowly throughout the inhabited part of the hillside, and then falls rapidly again, from below the lowest houses, down to the almost flat valley bottom. This profile is characteristic of the countryside in the densely populated parts of Uganda; even the lower hills, on which a rocky outcrop is lacking, have gentle slopes from the top to a long way down the sides, and then fall rapidly to the floor of the valley. The shape of the valleys cannot be attributed to erosion by the slow currents of water which percolate along them through forests or papyrus swamps.

It is more probable that the shape is due to the fact that, where the dwellings are, there the soils tend to be built up. That seems to be the most feasible explanation of the very deep deposits of even-textured red earths. Furthermore, there is much evidence that these soils have been and are being built up fairly quickly in some places; it is a common experience to see potsherds at depths of half a metre or more, even on hill tops; and, as the local pots are seldom very thoroughly baked and tend to disintegrate rapidly in moist soil, it is probable that these fragments are of no great age.

Evidence that the occurrence of red earths may be correlated with former human settlement is by no means confined to Buganda. It is plainly shown in some of the drier parts of Uganda and other East African territories and is easily seen from the air; the patches of red soil in some cases end abruptly, in other cases the colour grades into the paler shades of the land around. The patches of red earths are in places where supplies of water are available, or where it is probable that water has been available, and are usually on slopes well above the water table.

Much has been written about human influence on soil erosion in equatorial Africa; but there has been little mention of its function in building up soils in that region. Yet this accretion of soils on the sites of settlements is well known in other parts of the world, it is obvious in the case of many cities in Europe; and it is shown even more strikingly by the deep deposits of alkaline soils covering the remains of former civilizations in Egypt, in Iraq, and in northern India. If human settlement has caused the building up of soil in other parts of the world, it might be expected to do so in the tropics; and it seems to furnish the most reasonable explanation of the facts detailed above.

LATERITIC IRONSTONE

The origin of lateritic or red soils is a controversial subject; the origin of lateritic ironstone and leteritic gravel is even more controversial. Mackay (1943) has compiled an account of many theories on this subject. His observation that exposures of laterite frequently occur near old village sites in forest country and are probably quite a good indication of former forest clearance and cultivation is most interesting, and accords with the conclusion which had been reached after many observations in Uganda. Lateritic ironstone and lateritic gravel are common in the Protectorate and occur at many levels, on many rock formations and under a wide range, of climates—from the wettest to the driest. Outcrops of ironstone are found under a wide range of conditions, but the recent deposits have one feature in common—they are in places where it is probable that there have been human settlements. A major factor in determining human settlements is the supply of water, and it is very striking how often these outcrops are in places where water is available, although they are usually well above the present water table.

It has been suggested that lateritic ironstone has been laid down under water or on the shores of lakes or in places where there is a seasonal fluctuation of the water table; but there has been noticed no evidence of the formation of a layer of iron concretion in any such position at the present time on any of the hillsides described in this paper. And ironstone is abundant at many different levels; on the Sese Islands and on the shores of Kyagwe it occurs at the summit of the peneplain, but it is usually at lower levels in the north; and, even on a single hillside, as at Nansagazi, it may occur at several different levels. The discontinuous distribution of lateritic gravel, which appears to be derived from lateritic

ironstone, is well shown on the Kawanda Research Station; one end of the hill has red soil and much lateritic gravel, and the other end has shallow grey soil around an outcrop of quartzite; there are patches of gravel irregularly disposed on either side of the hill, not on the contour, but extending for some distance down the slopes.

And it has been suggested that ironstone may be formed by the rising of the soil solution; if this were the case, it could be expected that the outcrops would be horizontal, *i.e.*, parallel to the water table in the soil. But the outcrops are not always horizontal—often they are on a distinct slope, parallel to the surface of the ground. So that it seems more likely that the formation is due to concentration of the solution, as it percolates downwards, through meeting an impermeable layer; this would explain the incrustation of ironstone on rock surfaces. In the cases where the ironstone is formed in the absence of rocks, the impermeable layer may be the hard pan which often results from native cultivations—the soil being turned over to the same depth time after time—or by the compaction of the soil on which dwellings have been built. There is very little ironstone or lateritic gravel in places where the soils contain much coarse sand as, for example, those derived from granites in the Mubende district (to the west of the area described in this paper); however much these soils are compacted, they remain very permeable. Encrustments of lateritic ironstone are often to be seen on quartzites in Uganda, but not on granites.

One strong argument that ironstone is formed through some human influence is the manner in which both solid lateritic ironstone and lateritic gravel are found in patches even more horizontal than the red earths. It seems impossible to account for this sporadic occurrence, except through human agency. It certainly cannot always be attributed to the distribution of rocks; the unconformity of rocks and of lateritic ironstone and gravel may still be seen on the cuttings of a new road between Sipi and Sebei, on the north-west of Mount Elgon; these cuttings would afford valuable material for an intensive study by a soil chemist.

Some of the most striking examples of lateritic ironstone are to be seen on the promontory of Entebbe, and other headlands projecting into Lake Victoria, where the deposits are very deep; there is usually a shallow layer of lateritic gravel, then a hard layer of ironstone and then a softer, mottled mass to a total depth up to 8 or 10 m.; in some places the softer lower layers have been eroded, leaving the hard upper layer to form a cave or a natural bridge. The distribution of these masses of ironstone is very irregular—they are usually well developed on the headlands, and are usually absent in the bays. One of the most interesting occurrences is near the end of the Entebbe promontory, which runs towards the south-west—there is a line of regularly spaced outcrops projecting into the lake in the direction of due south. It seems scarcely credible that these outcrops can be due to 'natural' causes; and if they are due to human settlement, it is interesting to speculate why they should be thus arranged. Similarly, the circular outcrop of Nansagazi seems hard to explain on 'natural' grounds.

There appears to be no positive tradition that outcrops of ironstone are to be associated with human settlement, as is the case with the reddening of soil. But it is a significant fact that the spot which used to be most sacred to the Buganda, the site of the temple of Mukasa, their principal deity, was an extensive sheet of ironstone on Bubembe Island in the Sese group; for Mukasa, like the other gods of the Buganda, appears to have been a deified person, and the temple was built on the site of his dwelling.

Finally, one great argument that ironstone may be built up through human interference is the fact that it tends to diminish through natural causes. First, it is eroded rapidly by water, as is shown by native tradition; ironstone causeways, which connected islands in the Sese group, are now deep beneath the lake; the rock Sali at the south side of Bunjako Island, which was connected to the mainland by a strip of ironstone, is said to have floated away. Secondly, there is evidence that, when an ironstone pavement or lateritic gravel is under a forest cover, it tends to disintegrate, a process which may be seen on the Sese Islands, where trees grow well on such pavements (Thomas, 1941) and which has been noted in Nigeria (Rosevear, 1942) and on the Ivory Coast (Porteres, 1937).

There are considerable areas of ground in some densely populated parts of equatorial Africa which are rendered infertile by layers of lateritic ironstone. If, as seems probable,

these layers can be broken up by forest growth and the land rendered fertile again; such a process would be of great economic value; the processes by which the ironstone is built up and broken down seem to demand intensive study. It is possible that the processes are much more rapid than would be expected; at Nansagazi and on some of the islands near the north of Lake Victoria there may be seen cases of *Chlorophora excelsa* trees growing in crevices of ironstone pavements; as *Chlorophora* is a long-lived species and one that demands high soil fertility, it is possible that the ironstone has been exposed, or even has attained its present hardness, after the trees became established.

THE ANTIQUITY AND DENSITY OF HUMAN SETTLEMENT IN UGANDA

If such far-reaching changes of vegetations, of soils, and even of rocks are to be attributed to human influence, it is essential that there must be proof of long-continued human settlement in the country. Such proof is now available: Wayland (1934) has shown that not only can the same sequence of stone-age culture be traced in Uganda, as are known in Europe, but also that there was a far greater density of settlement here. In his M horizon in the valley of the Kagera River there is layer composed entirely of artefacts, embedded in a mass of lateritic ironstone. The horizon provides more evidence that ironstone may be connected with human settlement; similar tools are to be found in reddened earth of Bed 2 at Oldway in Tanganyika; the reddening may be caused by a change in climate but, by analogy with present-day conditions, it is possible that it was due, at least in part, to dense human settlement.

Life is easy on the northern shores of Lake Victoria. The climate is never very hot, never very cold, never very wet and never very dry. As the rainfall is so well distributed, a supply of food is relatively easily maintained, far more easily than in temperate regions with a long cold winter, for crops may be harvested at all times of the year and fish and game may be obtained at nearly all seasons. Clothing is unnecessary and housing may be of the simplest. It is only to be expected that primitive man, with a minimum of tools, should flourish and multiply here to a far greater extent than under more rigorous climates.

It seems that even fairly recently the population of the Uganda Protectorate was much greater than at the present time. Roscoe (1911) states that about 1860 the population of Buganda alone was about 3,000,000; now, although the area of the province has been increased, yet the population is only about 900,000. There was a tremendous wastage of population in the years before British rule commenced, a wastage due to wars, to famines, to disease, and to the human sacrifice and executions which seem to have accounted for thousands of victims each year.

Furthermore, if striking effects are to be produced on the soils there should be long continued human settlement in certain places. It is quite probable that large settlements would be made and continued on the islands and headlands on Lake Victoria, for the inhabitants of such settlements could resist attacks from their enemies. In dry areas there might be permanent settlements close to supply of permanent water—the rivers and waterholes which did not dry up at any season of the year. But, in a well-watered area like the south of Buganda, it should be possible to change settlements at frequent intervals; and so long as cultivation was in the primitive form of cutting down the forest, taking a few crops off the soil until it lost fertility and then moving on to fresh areas, so long as this system of agriculture continued, no permanent settlement could be expected.

But permanent settlements, based on the cultivation of a perennial crop, the banana, appear to have been a feature of Muganda life for a long time. There is often a connection between the antiquity of a crop and its religious significance; and, as Roscoe shows, it was the banana crop on which the life of the Buganda was centred, the crop with which the ceremonies of birth and death were connected, which was used to give protection from sickness and which supplied offerings for their gods.

Yet the banana is not an African plant; it originated in south-east Asia; it sets no seed and can only be grown from suckers, heavy pieces which the African would be unlikely to carry for many miles. Nevertheless, there were over thirty varieties of banana in Uganda before the coming of the Europeans; a few may have arisen by bud mutation, but

the majority must have been introduced. If climatic conditions at the time of introduction were like those of the present day, it is unlikely that the bananas were brought to Uganda from the east, north or west; the southern route, down the western side of Lake Victoria, the rift of Lake Tanganyika and the Zembesi valley to the coast, seems to be the most likely, for it alone provides an uninterrupted stretch of inhabited country suited to banana cultivation. An even greater mystery than the manner in which so many varieties can have been brought all the way from the coast to the centre of the continent is the manner in which the bananas reached Africa at all—were they brought by the Portuguese, or by the Arabs before them, or by the Chinese, who appear to have been the first people to carry on a regular trade by sea with Africa?

However the bananas may have reached Uganda, there is no doubt that they have been cultivated to the north of Lake Victoria for a very long time and on a very extensive scale. The bananas are deep-rooted plants and respond greatly to soil fertility—they will not grow on poor soils; so the African plants his banana garden on the best available land and builds his house in it. The ashes, the refuse of food and the manure from stock tend to accumulate near the house, maintaining and increasing the fertility of the soil, so that a well-kept banana garden may persist for a hundred years or more. On poorer soils, the life of a banana garden will be much shorter and the land must be left for a spell under a fallow of elephant grass or of a secondary forest before it recovers sufficient fertility for another crop of bananas to be grown. Even if the banana gardens have a short individual life, yet there is a tendency for them to be replanted again and again on the same piece of land and there is a tendency for plant nutrients to accumulate in such areas; whereas the land nearby which, if it is under forest is used to provide firewood or, if it is under grassland is used to provide grazing and thatching material, tends to become further depleted of its nutrients. Thus there may be produced the striking differences of soil fertility between the zones on any one hillside.

THE INDIRECT EFFECTS OF HUMAN INFLUENCE ON VEGETATION

It has seemed necessary to digress from botany into the more controversial sciences of anthropology and soil science in order to appreciate the indirect effects of human influence on vegetation. For the direct effects may produce temporary changes; but the indirect effects may produce permanent changes. If a field of grassland is burnt, it may be expected that the grasses will spring up again in the next rainy season. But if a forest is felled, and the land is cultivated and exposed to the deleterious action of sun and rain for a long period, the mineral status of the soil may be so much lowered that the woody species cannot regenerate and open grassland replaces the forest.

Any disturbance of the natural cover of the soil is likely to increase the rate of leaching and the ultimate loss of plant nutrients; it would be interesting to analyse the waters of the River Nile and to calculate the amounts of various salts which are carried down each year from the Lake Victoria basin to fertilize the farmlands of Egypt. But human influence is not always destructive of soil fertility; just as the farmlands of western Europe are probably now much better supplied with plant nutrients than when they were under temperate forests (especially in the case of areas which were under coniferous forests) so also it is probable that the soils of the banana gardens in Uganda have now a higher mineral status than when they were under tropical evergreen forest.

Yet it is probable that the mineral status of the grassland soils has been lowered and is still being lowered; the salts being taken up by the grasses are carried away by the animals which graze on them and a high proportion is not returned to the grasslands, but is deposited on the spot where the animals are kraaled at night. As the mineral status of a soil is diminished, the composition of its herbage changes (Thomas, 1940). In those parts of Uganda which have well distributed rainfall, *Pennisetum purpureum* grows on the richest soils, *Cymbopogon afronardus* on those which are poorer and *Loudetia kagerensis* on the poorest of all.

The change in the composition of the herbage appears to have a great influence on the surface soil, not only as regards its structure, but also as regards its mineral status. A large collection of grasses has been planted at Kawanda Research Station on fairly good soil: it has been found much easier to establish species

such as *Pennisetum purpureum* and *Cynodon plectostachyum*, which grow on good soils, than to establish species such as *Eragrostis chalcantha* and *Loudetia kagerensis*, which grow on poor soils. The reason seems to lie in the differences between the root systems of the grasses: as a general rule, the species which grow on good soils have vigorous, deep, roots, but the species which grow on poor soils have weak, shallow, ones. Therefore if it is only possible for these latter species to grow, the minerals in the deeper layers of soil and subsoil are much less available to the herbage than if more vigorous species are growing, and it may be expected that more of the salts will be leached out by percolation of soil water. The *Loudetia kagerensis* grassland on the hillside at Bujumba furnishes an example of such a soil: it is very permeable and is of great depth, and yet the grass roots can draw upon only the leached upper layers. The seedlings of trees are unable to become established in this poor soil, except close to termite mounds where the mineral status of the surface soil is higher.

Whenever forest does not invade an area enjoying an equable temperature and a good well-distributed rainfall, with no water-logging, it is usual that the poverty of the soil is an inhibiting factor. This poverty may be due to the fact that the soil has been leached before it is deposited, in which case podsolization may take place, even under tropical conditions (Richards, 1941); such deposits may be seen near Lake Nabugabo in the Masaka district, in the north-west corner of the area included in the map (Thomas, 1942b). Yet it seems that instances of such poor natural soils are not very common in the tropics and that most of the areas of permanent grassland in close juxtaposition to tropical evergreen forests are due to soil degradation by human influence.

And so it seems that by removal of the nutrients from some zones and their concentration in others, a pattern of soils differing in colour and in mineral status has been built up, such that the most fertile soils are often to be found on the tops and sides of hills, and not near their bases, as would be expected from ordinary soil-forming processes. This diversity of soils is reflected in the diversity of vegetation with communities differing greatly in composition and life form, instead of the more uniform vegetation which probably existed before the coming of man.

Not only do the soils differ greatly in mineral status from zone to zone, but also there are great local variations inside the zones. Termites and some mammals, which tend to place their excreta in certain spots, may cause local accumulations of plant nutrients; but it seems that most of the variability of the soils must be ascribed to human influence.

—*The Journal of Ecology*, Vol. 33, No. 2, July 1946.

EXPANSION OF PLANT SYSTEMATICS

The Systematics Association held a very successful meeting at the Herbarium, Royal Botanic Gardens, Kew, on the afternoon of October 5. Members were welcomed by Sir Edward Salisbury, director of the Gardens, who briefly outlined the long service of Kew to plant taxonomy and the intimate co-operation between the various departments with the common aim of advancing research in the many problems of plant classifiaction. He was pleased to see such a large attendance, and was certain that the exhibits so carefully prepared by members of his staff would arouse much interest.

The theme underlying the series of exhibits was to illustrate examples of the diversified problems involved in plant systematics, the various methods of investigating such problems, and some of the results obtained. The exhibition occupied the ground floors of two of the large wings of the Herbarium, and consisted of living plants, herbarium and museum specimens, microscopic preparations, books, manuscripts, diagrams, charts, and maps, with considerable and pleasing individuality shown in the arrangement of the various subjects. In spite of the intentionally wide range covered by the sum of the exhibits, the general *motif* of plant classification obviously unified the whole series.

The history of the progress of botanical taxonomy from 370 B. C. to A. D. 1946 was illustrated by a collection of books and manuscripts selected from the Kew library, which now contains more than 50,000 volumes. Many rare and valuable works were shown, and emphasis

was laid on those which marked noteworthy advances in plant classification. Another series of botanical books (about thirty in number altogether) showed something of the activities of the Kew staff in very recent years. Attention was directed to the large exhibition of paintings and drawings demonstrating the history of botanical illustration from 120 B. C. to A. D. 1946. A selection of original paintings for the *Botanical Magazine* and of paintings of dissections of plants difficult to preserve adequately showed the value of hand colouring in the making of permanent records of living plants. The importance of drawings in the revision of genera was exemplified by *Sphoeranthus*, *Camellia*, and *Streptocarpus*. A selection of original drawings, with dissections, for a new work on the British Flora now in preparation were remarkable in their combination of artistic merit with scientific accuracy and adequacy.

Two large families, those of the orchids and the grasses, served to illustrate the difficulties of classification due to incomplete correlation in different categories of characters. In *Polystachya*, a large genus of Orchidaceae, only some of the accepted sections are natural in the sense of being based on a full correlation of characters. Other sections are distinguished only by one or two characters and show much reticulation with other sections. The tribes and genera of the Gramineae provide even more striking examples of reticulation. This was illustrated by the spicate inflorescence in relation to a wide range of other morphological, anatomical, and cytological characters. The emphasis, in earlier classifications of the grasses, on the gross structure of the inflorescence resulted in some very unnatural groupings. By taking a more synthetic basis, a much more generally satisfactory division into major tribes has been obtained, though problems of parallelism and reticulation still remain, especially those of causal and phylogenetic interpretation. *Lepturus* and segregated genera represent particularly well some of the problems involved and their possible solutions. The desirability of major changes in classification was also made clear in the genus *Carex*, which has more than a thousand species. Detailed morphological and distributional studies have suggested classificatory sequences which reveal possible phylogenetic lines linking tropical and temperate species. Problems of 'relationship' were further demonstrated by the occurrence of similar characters in groups widely sundered in well-known systems of classification. For example: Symplocaceae, Rosaceae, and Theaceae; Anonaceae and Aristolochiaceae; Ochnaceae and Primulaceae; and Magnoliales, Hamamelidales, Aceraceae, Platanaceae, and Lauraceae respectively show some characters in common. *Pentaphragma* has been referred to both Campanulaceae and to Saxifragaceae, and, more recently, has been made the type of a new family, Pentaphragmataceae, which anatomical characters suggest may be related to Begoniaceae. On the other hand, a long-established group like the Glumiflorae is probably based on superficial resemblances, particularly of habit: the sedges and rushes are better classified with or near to the liliales, and the grasses perhaps placed near the Zingiberales. Odour is determined by chemical constituents of plants; similarities in these are, or may be, taxonomically valuable characters. It is, at least, not to be ignored that 'valerian' odour occurs in *Valeriana* (Valerianaceae), *Viburnum* (Caprifoliaceae), and *Pentstemon* (Scrophulariaceae), and the 'fenugreek' odour in *Trigonella* (Leguinosea) and *Lysimachia* (Primulaceae).

Similar difficulties to those met with in classifying seed-bearing plants also occur in the Cryptogams, sometimes with further complications. The genus *Psalliota* (the mushrooms proper) consists of 'species' or 'microspecies' extremely difficult to separate one from another by any definite, and constant, characters. With such fleshy organisms, adequate paintings of living plants are essential as permanent records. In the smuts, so-called 'physiological races' occur which are morphologically indistinguishable but are limited to different hosts; while, conversely, on the same host morphologically distinct kinds may occur. Hybridization frequently complicates the work of the taxonomist, and the occurrence of hybrid swarms is being frequently proved. The Robertsonian saxifrages, as they occur in Western Ireland, were used to exemplify, by a fine series of recently collected specimens, the possibilities of unravelling the tangle resulting from interspecific crossings. The results of controlled hybridization combined with cytological investigation were indicated by living plants,

dried specimens, and paintings, in: *Saccharum* X *Sorghum* hybrids; X *Sacchariantlius coimbatoriensis* ($2n=132$), a hybrid between *Saccharum spontaneum* ($2n=112$) and *Erianthus ravennoe* ($2n=20$); and X *Euchloezea mertonensis* ($2n=30$ and $2n=40$), a perennial hybrid between *Euchloena perennis* ($2n=40$) and *Zea mays* ($2n=20$). Seeds and living plants of *Ricinus communis* from Manipur State showed the genetic nature of certain 'varietal' characters. The cytology of species of *Magnolia* has proved the existence of diploids ($2n=38$), tetraploids ($2n=76$), and pentaploids ($2n=95$), and correlation between the chromosome number, geographical distribution and morphological features.

Taxonomic investigations can only be adequately conducted as a large central institution, since taxonomy is essentially a comparative study, and large series of specimens are a *sine qua non* for reaching sound conclusions. It follows that the taxonomist is dependent in a very large degree on field collectors and to well-trained collectors he owes a great debt. The need for much more intensive collecting, particularly in tropical areas, throughout the seasons in any one locality was well shown by an exhibit of precocious development in tropical African plants of savanna communities. In many species the flowers and leaves develop at different seasons, and a travelling collector often collects only flowering or only vegetative material. To know the seasonal life-history is a taxonomic need. This was further illustrated by some South American plants with comparisons between seedling and adult states (*Chondodendron candicans, Cassia spp., Catostemma spp.,* and *Apeiba petoumo*). Juvenile characters may, or may not, be apparent in the mature plant, but are always of taxonomic importance. Ontogeny was also illustrated by living sporelings and beautiful microscopic preparations from fronds of different ages of the fern-royal (*Osmunda regalis*). The nature of the venation and the outline changing with increasing age were very clearly demonstrated.

The taxonomist is always concerned with distribution, both as a help in understanding causes and for its own sake. Two exhibits were concerned with plant geography. The phytogeographical regions of extra-tropical Eastern Asia were illustrated by large—and small-scale original maps showing correlations between the ranges of taxonomic groups and plant communities, physiography, and climate. Specimens of *Notholirion, Poeonia, Nomocharis, Malus, Tulipa, Tripterygium,* and *Camellia* were chosen as examples of the researches on which the synthetic results have been reached. The great sub-continent of India has not only a rich endemic element of its own but also has received floristic contributions from neighbouring lands, especially from the east and north-west. Emigrants (generic or specific) from the Eastern Mediterranean flora are well marked in the Cruciferae, Fumariaceae, Capparidaceae, Caryophyllaceae, Rosaceae, Labiatae, and Boragineceae. Routes of migration were shown on a map, and migrants selected from the above-mentioned families were used in illustration.

In modern taxonomy, full and carefully prepared descriptions are demanded. Sometimes statistical methods can be applied with advantage. Unfortunately, the combination of taxonomist and biometrician is rare, and few statistical methods have been devised for the special use of the taxonomist. The attention of biometricians might well be directed to this fact. The genus of the elms (*Ulmus*) has recently been investigated by the use of new criteria based on specially devised statistical methods, and an exhibit illustrated these methods and the results obtained by their use.

While much taxonomic work has to be based on gross morphology, there is increasing recognition of the need for correlating this with anatomical structure. Anatomical methods have great use, and some acknowledged limitations, in taxonomy, as have all taxonomic methods in isolation; but the forthcoming publication of a new work, prepared at Kew, on the anatomy of Dicotyledons will stimulate interest in the subject. An exhibit illustrated the diagnostic value of the internal microscopic structure of the leaf, petiole, stem, and secondary xylem, as well as that of microchemistry.

Taxonomists working at Kew are fortunate in having not only the great collections in the Herbarium and library at their disposal, but also in being able to study a wide selection totalling some 45,000 species (excluding culti-species) in the living condition in the Gardens. The need for experiments, with taxonomic aims in view, on living plants

is fully realized, and it is intended to increase facilities in this direction. One exhibit illustrated the need for caution in reaching taxonomic conclusions previous to such experiments. Transplant experiments with *Plantago major* have shown the high plasticity of this species and proved that some so-called 'subspecies' and 'varieties' are no more than 'habitat forms'. In *P. coronopus*, phenotypic diversity is even greater than it is in *P. major*, but until controlled experiments have been made, the separation of genetically distinct varieties and habitat phenotypes of one genotype is impossible.

Taxonomy has to serve all branches of biology—hence its basic importance. A convincing demonstration of its use in applied botany was provided by an arrangement of specimens of *Sorghum* and *Cymbopogon*. The former genus gives one of the world's most important cereals, providing a staple food to millions of human beings as well as to livestock. For many years there was much confusion over the numerous cultivated species and varieties. An intensive and extensive study at Kew resulted in the production of a standard monograph which has been invaluable to economic botanists. *Cymbopogon* is a genus of grasses yielding essential oils. Previous to a detailed taxonomic study, it was not possible with certainty to determine the source of any particular oil derived from a species of *Cymbopogon*.

Particularly striking general features of the exhibition, as viewed by a visitor, were the wealth and diversity of the interesting problems raised by studies grouped as taxonomy, the almost innumerable treasures housed yet accessible at Kew, the considerable progress being made in taxonomic research, and the broad outlook shown by the modern taxonomist, with his full appreciation of the help he can give to and the help he can obtain from his colleagues in other branches of biology. Visitors engaged in the teaching of biology must have received many suggestions.

At the business meetings, the Systematics Association was placed on a firmer foundation than hitherto by the adoption of a simple set of rules. All biologists interested in problems of classification and evolution are invited to join the association and take part in its increasing activities. Particulars can be obtained from the secretaries: Dr. R. Melville, Royal Botanic Gardens, Kew, Surrey, and Mr. H. W. Parker, British Museum (Natural History), South Kensington, S. W. 7, or from the treasurer, Mr. E. B. Britten, British Museum (Natural History).

—*Nature*, Vol. 158, No. 4016, October 19, 1946.

TREE PRUNING BY ANNUAL REMOVAL OF LATERAL BUDS

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Pruning of young trees to increase the value of the butt log is receiving increasing attention. The experiments described in this article indicate both advantages and disadvantages in the pruning of red pine by removal of lateral buds, with further work needed to determine the relative effectiveness of the method.

A new method of tree pruning to produce knot-free lumber, originating in Russia, is being tested in the Nicolet National Forest of northeastern Wisconsin by the Forest Products Laboratory. By this method, the lateral buds that cluster about the terminal bud of some species are removed each year, thus preventing the formation of branches along the trunk until the tree reaches a desired height, after which it is allowed to grow branches and crown out normally.

About 200 trees are being pruned annually by this method. They were planted in the fall of 1933, and treatment was begun in 1940. The first few sets of branches were allowed to grow in order to nourish the tree while the experiment is in progress. Removal of the lateral buds will be continued for another 5 or 6 years before the trees are permitted to resume normal growth.

Russian Experiment

The method was developed by P. G. Krotkevich at the Kiev (Russia) Forest Institute[2]. His article describing it was reviewed in the

[1]Maintained at Madison 5, Wisconsin, in co-operation with the University of Wisconsin.

[2]Krotkevich, P. G. Novy method vyrashchivania olrevesiny sosny bez suchiev. [A new method of pruning.] Lesonoe Khosiaistvo. [Forest management], Goslestekhizdat, Moscow, No. 1, pp. 35-38, 1939.

JOURNAL OF FORESTRY for October, 1940 (38: 819-20).

The Russian experiment was continued until the main stem of the tree had reached a height of 18 to 20 feet, after which it was allowed to produce a normal crown. As the crown closed over, the branches at the base of each tree were removed or allowed to die as a result of shade. During the course of the experiment, the trees were nourished by the four or five branch whorls near the ground and by needles on the main shoot, which became unusually long and vigorous in appearance. The Russian report stated that stems of treated trees were thicker than those of untreated trees, but height attained remained about the same as that of untreated trees. The experiments were carried on with pine, presumably *Pinus sylvestris*.

Red Pine Plantation Tested

The wide interest in forest pruning stimulated by the work of the Civilian Conservation Corps led the Forest Products Laboratory to test the Russian method with native red (Norway) pine (*Pinus resinosa*).

The area selected in the Nicolet National Forest was an old field prior to planting with red pine, 2-0 stock, in the fall of 1933. The trees were planted in furrows approximately 8 feet apart and spaced 6 feet apart in the rows. Vacant spaces created by the loss of a number of trees during the ensuing dry summers were replanted with jack pine in the fall of 1936. At the time of the initial debudding treatment in 1940, the red pine trees ranged up to 3 feet in height.

Red pine trees for treatment were chosen in alternate rows. Where no blanks existed, each third tree in the row was treated. This spaced the 200 treated trees roughly 16 by 18 feet apart over an area of about 200 by 300 feet.

Only lateral buds of 1939 growth were removed by the initial treatment on June 6, 1940. It was, therefore, possible to give the trees a second treatment the same year after the 1940 terminal growth had ceased and the lateral buds were formed. The second debudding treatment was given on September 18, 1940.

Development of Woody Shoots

In the initial treatment of June 6, it was found that short woody branches up to 1 inch in length had developed from some of the lateral buds in the previous year's growth, making the use of a scalpel or scissors necessary in order to remove all of the lateral growth. The first time this short-branch formation appeared it was attributed to early spring growth of the trees. Similar small branches, however, were found in considerable numbers at the time of the second treatment. Again the use of a scalpel was necessary to remove them. From these experiences, it was concluded that lateral buds should be removed earlier, possibly the latter part of July, in order to eliminate the need of a cutting instrument for bud removal.

Comparison of Costs

The cost of pruning by the Russian method probably would compare favorably with other methods if only the actual time spent in removal of buds is considered. Individual treatments thus far usually have required less than 1 minute per man per tree for the lot of 200 trees. Treatments in subsequent years will require somewhat more time because of the necessity of using a ladder, as was the case in 1945 for about one-third of the trees, the tallest of which had reached 13 feet in height. Most of the trees are about 7 to 8 feet in height and will require from 4 to 6 additional treatments, depending on rapidity of height growth, before the experiment can be considered complete.

In view of some of the difficulties encountered thus far, it seems advisable to start a number of experiments, some of which should be varied from the original plan, with several different species, in order to discover the most practical method of pruning by annual removal of lateral growth.

One advantage that appears to stand out in favor of the method is that of early removal of lateral growth of trees before it reaches large proportions which entail much labor for removal of branches and to clear them from a stand in order to reduce the fire hazard. The production of a butt log free from overgrown pruned branch stubs also merits consideration in comparing the method with conventional pruning procedures.

Accordingly, the 1941 treatment was given on August 7. Again it was found that small branches had formed on many of the trees, requiring the use of a cutting tool for their

removal. In trees where such woody side shoots had not developed, the lateral buds surrounding the terminal bud were broken off easily by pressing them downward with the thumb and index finger. In the light of subsequent experience, it is believed that growth of the short woody branches would have been prevented if the treatment had been given even a few days earlier that year.

The trees were not treated during 1942 or 1943. Treatment was resumed in 1944 when, on August, 9, the lateral branches of the 2 preceding years were cut off with pruning shears and the current lateral buds were removed by hand. On this occasion, although the debudding was performed 2 days later than in 1941, practically no woody branches such as had been found on the three previous occasions had developed with the lateral buds.

In 1944 a ladder was required in order to reach the terminal buds of some of the faster growing trees.

In 1945 treatment was given the trees on July 27. From the standpoint of ease of bud removal, the buds, on this date were in the best stage of development. There was not yet any growth of short woody laterals. All of the buds crumbled off easily when pressed downward with the fingers.

Advantages of Method

In the original Russian paper, four advantages of pruning by removal of lateral buds were listed:

1. Shortness of time required to produce wood suitable for aircraft.
2. Better development of commercial timber than by former methods.
3. No infection of the trees by fungi.
4. Simplicity of the care of trees in comparison with other pruning methods.

Difficulties Observed

On the basis of the progress of the Forest Products Laboratory experiment thus far, no exception can be taken to the above statements. It seems advisable, however, to point out certain difficulties that may in some cases become of considerable importance.

It has already been shown that, for red pine, the season for easy removal of buds is of short duration following cessation of terminal height growth each year. This may be a species characteristic or the result of certain climatic influences resulting in woody shoot development soon after the current lateral buds are formed. At any rate, in three of five treatments it proved to be a definite hindrance in the application of the methods because of the greater difficulty of cutting the short branches than of breaking off the buds.

After two treatments in 1940, it was found at the time of the 1941 treatment that prolific bud development on some of the terminal shoots presented another difficulty. Buds were so numerous that a terminal bud could hardly be recognized among them. The many buds to be removed also caused some delay in the progress of the work. With a laps of treatment for two seasons during the war, the tendency toward such behavior in bud development seems to have disappeared. Some trees developed numerous side branches the first year treatment was omitted. There remains, however, a likelihood that the condition may return following two or three successive treatments.

A third factor affecting the utility of this method of pruning is the risk of losing treated trees as the result of injury, particularly insect injury to the terminal shoot. Some trees may have the ability to initiate new buds that can continue height growth in place of a dead terminal bud. In other cases, especially after injury by white pine weevil, the main stem may become a total loss. This has happened already in several of the trees in this experiment. In such cases, the tree may be salvaged by allowing one of the branches from a lower whorl to become the leader. Such a tree, however, would act more as a filler than as a crop tree and would probably fall behind surrounding trees that had gained an advantage in height growth. Moreover, the large crook at the base would make the wood in that portion of low quality because of the formation of compression wood.

In the Forest Products Laboratory experiment, many of the branches of the lower whorls developed vigorously, and in some cases it was deemed advisable to cut them back to prevent the formation of a double or candelabra tree. Doubtless this thrifty growth was due in great measure to the initial wide spacing of the trees.

INNOVATION SUGGESTED

It is still too early in the experiment to warrant a final decision on the merit of this method of pruning. Developments thus far suggest the need of further experimentation with several species before the method can be endorsed wholeheartedly.

An innovation that may deserve trial is the annual removal of 1-year-old lateral branches instead of the buds. In case of injury to the terminal bud, one of the current side branches could then be left to replace the lost terminal shoot, and height growth would continue with only slight delay. The time required to remove 1-year branches with hand clippers would be slightly more than that needed to break off buds in the proper condition, but no longer than when scissors or other cutting instruments are used for removal of short woody shoots. The season for removal of side shoots would be much longer than that found suitable for removal of lateral buds. The scars from the 1-year-old side branches would be of no consequence in the lumber because of their nearness of the pith.

—*Journal of Forestry*, Vol. 44, No. 7, July, 1944.

PRUNING FOREST TREES BY THE FINGER-BUDDING METHOD

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The experiment described below adds to the information concerning finger-budding presented in the preceding article, with substantially similar indications as to the advantages and disadvantages of the method

The method of pruning coniferous forest trees by removing the lateral buds from the leader of young trees each year probably originated in England in the late 18th century.[1] It was first used primarily to grow straight oak for ship timbers but was later adapted to produce knot-free wood. The usefulness of the system with some American tree species is being tested experimentally on the university forest, a property managed by the Department of Forestry of the University of Maine on long-term lease from the federal government.

The experiment described here was started in 1941 and the initial pruning continued through 1942 and 1943 in two plantations of red pine and one of Scotch pine planted in May, 1936. Original data collected were pruning time, travel time (from tree to tree), height of trees, and total number of branches. Total number of branches, rather than whorls, was recorded because the latter were irregular in the number of branches they contained often having as few as one. White spruce was originally pruned but abandoned after one year because of attack by the white pine weevil and the habit of the species to produce branches from the internodes of the main stem. In general, the work has paralleled that described by Mr. Paul in the foregoing article but with a few significant differences in procedure and results.

PROCEDURE

Buds were pruned annually in early June. It was soon discovered that care must be taken to avoid damage to the remaining bud of the leader, so easily are the buds removed when height growth has started. During the operation only pruning and travel times were recorded; growth data were collected subsequently. Because the trees of the three plantations had developed irregularly (the red pine varied in height from 1.2 to 5.8 feet and the Scotch pine from 1.2 to 5.5 feet), the spacing of pruned and check trees was uneven. Since they were located and examined by row and tree number, more time was probably spent in travel than would ordinarily be the case. An attempt was made to choose pruned and check trees of approximately the same height, fairly close together, and where they would not be over-topped subsequently by neighbors. Growth was recorded after 2-year periods. By 1945 the majority of the trees had experienced 4 years' growth since pruning.

A special ladder for pruning buds out of reach from the ground was constructed and

[1] Curtis, James D. An historical review of artificial forest pruning. Forestry Chron. 13:380-95, 1937.

proved very satisfactory. Designed along the general lines of an orchard ladder, the two uprights holding the rungs were a foot apart at the bottom and 3 inches at the top. Two legs with pointed strap-iron tips were connected to the top of the ladder by a bolt through projecting strap-iron cleats on the top end of the legs and the ends of the ladder. Each of the two legs could thus move independently some 6 feet from side to side and outwards as far as necessary for stability.

Difficulties Encountered

Although only five growing seasons have elapsed since the start of the experiment, certain difficulties in this method of pruning are obvious.

Development of Woody Shoots

In common with Paul's difficulty, though not to the extent he experienced, occasional woody shoots were found on leaders. These were presumably a "fascicle shoot" from a leader already pruned, or fall growth from a bud formed at the end of the growing season. In order to save time, those produced by the latter cause were torn off—perhaps unwisely—although no serious wound resulted.

Leader Damage

Greatest damage to leaders resulted from fresh spring winds in the more exposed of the red pine plantations. On unpruned trees (even some of these were similarly damaged) the laterals curled upward against the leader, thus protecting it from all directions against much movement. On pruned trees, where these laterals were absent, the succulent weak leaders were snapped off—usually several inches above the last node. Most were completely severed; others were "bent" at various angles and continued to live, but had to be removed because of their great angle with the main stem. Several trees lost their leaders from unknown causes, possibly from perching birds. Crossbills and evening grosbeaks aggravated the situation by debudding leaders and laterals of Scotch pine.

While none of the red pine leaders was damaged by the white pine weevil, the Scotch pine was so severely attacked that on 50 per cent of the trees the first whorl of branches below the first bud-pruned whorl had to be pruned by saw to eliminate several new leaders. As Paul points out, when the leader is damaged for any reason, the tree loses some dominance and often falls below its neighbors in height.

"Fascicle Shoots"

Numerous buds developed from the stem leaf fascicles when a leader was killed, usually just below the point of damage. While their appearance was a saving grace, providing as it did a choice of new leaders, the removal of unwanted ones was time consuming, particularly on the Scotch pine where they had to be cut off rather than rubbed off. Furthermore, with the Scotch pine, they developed into woody shoots at various places on the stem which involved even more time in their removal by a knife. Fascicle shoots intended for new leaders were chosen on the "side" of the stem facing the prevailing wind.

Growth of Original Laterals

It was observed, as in the Lake States experiment, that the original laterals on the first few feet of the pruned stems prompted the development of what Paul aptly describes as a "candelabra" tree. The higher the tree when pruned, and on trees whose leader was severely damaged, the greater was the tendency. It was difficult to gauge when these vigorous branches were seriously affecting height growth and should be removed partially or entirely.

Advantages and Disadvantages

The advantages of the method appear to be:

1. It produces the maximum amount of clear wood per tree.
2. There is small likelihood of fungus infection.
3. Less time is required to produce a given volume of clear wood.

The disadvantages as judged by the progress of this experiment are:

1. It must be confined to trees whose leaders are not attacked from a known cause.
2. Damage may occur to the leader of any species.
3. The remaining branches tend to grow vigorously and to produce trees of the "candelabra" type.
4. The indications are that costs will be higher than in the usual method of pruning with a saw.

Results

So many of the Scotch pine had developed into undesirable individuals by the end of 1945 that it has been decided to discontinue pruning them.

Pertinent data and calculations from measurements are presented in Table 1. There is no significant difference between the growth of

pruned and check trees after either the 2-year or the 4-year periods, but the average clear length and also the periodic height growth of pruned trees would be substantially higher if no damage to leaders had occurred. Although new leaders can be grown satisfactorily on leader-damaged trees from one of the many "fascicle shoots," a year's growth is lost in the meanwhile and extra time is required to correct the situation.

Probably the most important item in the table is the time that has been required to produce the average clear lengths in each of the three plantations. Calculated on the basis presented by Hawley[1] of 4 to 12 cents per tree to prune a 17-foot clear length, figures of 7.5, 6.0, and 8.3 cents are obtained, with labor at 60 cents per hour. It is questionable, in the writer's opinion, if the pruned trees can be completed to an average clear length of 17 feet for less than 25 cents per tree if the difficulties described herein continue to be encountered, particularly since costs rise the higher pruning is carried up the stem. This estimate is not so optimistic as that of Bickerstaff[2] who, in a carefully planned, similar experiment with red pine, concludes that 10 man-minutes, or 10 cents per tree, will be the total required.

TABLE 1.—NUMBER OF TREES, TOTAL PRUNING TIME GROWTH DATA, AND DAMAGE FOR PRUNED AND CHECK TREES OF RED AND SCOTCH PINE AFTER FIVE GROWING SEASONS

	Red pine 1	Red pine 2	Scotch pine
Number of pruned trees	49	33	48
Number of check trees	48	32	45
Average number of branches			
Pruned trees	10.5	14.5	17.0
Check trees	11.5	13.5	18.0
Average height at first pruning, ft.			
Pruned trees	3.2	3.7	3.6
Check trees	3.2	3.5	3.6
Pruning and travel time, min. per tree	2.9 (4.2)[1]	2.2 (3.5)[1]	2.8 (3.5)[1]
Average clear length, ft.	6.1	5.9	5.3
Two years' growth, ft.			
Pruned trees	2.3	2.6	2.1
Check trees	2.4	2.6	2.5
Four years' growth, ft.			
Pruned trees	4.9	4.6	5.4 (2)[2]
Check trees	5.8	5.2 (14)[2]	3.7 (2)[2]
Leaders killed			
Pruned trees	18	7	13
Check trees	..	..	9

[1]Figures in parentheses are the average number of prunings per tree.
[2]Figures in parentheses indicate the number of trees involved where this number falls below the total because of the date of pruning.

Bickerstaff experienced little or no damage to the leaders nor abnormally vigorous growth of the remaining laterals. In addition to this item, some trees adjacent to those pruned and damaged would have to be removed before they were salable because of their dominance, thus adding to the total cost. When the experiment is concluded it will be determined whether this total cost will more than offset the early returns on the clear wood produced.

CONCLUSIONS

1. This writer agrees with Paul that more experimental data and elaborations of the original idea of debudding are needed to decide whether or not this method of pruning is suited to conifers in this country.

2. Damage to leaders from climatic agencies can be expected, especially in exposed locations or where fresh spring winds are the rule.

3. Indications of cost are that more time will be required to produce 16-foot butt logs free from branches by this method than by saw pruning.

4. In order to keep individuals of the "candelabra" type to a low number trees should be first pruned when 2.5 to 3.0 feet high.

5. Any species of conifer whose leader may be killed by a common, anticipated cause such as the white pine weevil is not suited to pruning by the finger-budding method.

6. A given volume of clear wood can apparently be produced in a shorter time by this method than by the conventional methods of saw pruning.

—*Journal of Forestry*, Vol. 44, No. 7, July, 1946.

[1]Hawley, R. C. Practice of silviculture. 4th edition P. 205, John Wiley and Sons, New York. 1937.
[2]Bickerstaff, A. Knot-free red pine by debudding. Silvicultural Res. Note No. 76. Dominion Forest Service, Ottawa. 1945.

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SOIL EROSION SURVEYS *

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Introduction

Soil conservation in its broadest sense implies permanent maintenance of the productive capacity of the land. The achievement of soil conservation not only requires that the land be used for the purposes for which it is best suited, but also necessitates the adoption of such soil conservation practices as are required for each kind of land. Land use and soil conservation measures to be successful must be adapted to the physical conditions of the land. The land use and soil conservation measures that are put into practice may be modified or controlled by other factors such as local economic or social conditions but the basis must be developed in accordance with a physical inventory particularly of soil conditions, slope of land, character and degree of erosion, and present land use.

The United States have very serious problems of erosion due to misuse and over-working of land and in their efforts to set things right have had a fair experience of taking these physical inventories or soil erosion surveys. We should make the best use we can of their experience, and the attention of the conference is therefore drawn to the work of G. L. Fuller, A.E. Kocher, A. H. Paschall and J. G. Steele who did the earlier work in trying to systematise soil erosion surveys, and in particular to the SOIL CONSERVATION SURVEYS HANDBOOK prepared in 1939 by E. H. NORTON, the principal soil scientist of the physical surveys division of the U. S. Soil Conservation Service. In this paper an attempt is made to bring out the salient points of American experience to help officers engaged in erosion surveys to adapt this American experience to Indian conditions.

Details of one of the few soil conservation surveys that have been carried out in India are given by Dr. Gorrie in a separate paper.† The detailed experience gained in that survey should be carefully compared with the general principles evolved in American practice and noted in this paper, for we have very little experience of soil conservation surveys in India, a vast amount of work must be done, and we must make the best use of what little experience we have. A little practical experience is worth a wealth of theory.

The vital importance of deciding beforehand as far as possible exactly what one is aiming at and how one proposes to achieve these aims in a erosion survey cannot be over-emphasised. It is absolutely useless to start a survey unless one knows exactly what information is wanted and how it is to be collected. In addition, the field work of the survey itself is an ideal opportunity of getting the local people interested in the problem and to sow the seeds of the knowledge of how to solve it.

Conduct of the soil conservation surveyors towards the public

A tactful surveyor can make a scheme whereas one without the knack of getting on with people can mar it. The conduct of the fieldman to the public must be tactful and courteous at all times. He is one of the first men of the service to contact the man on the land and first impressions are lasting. The surveyor should endeavour to answer all pertinent questions in a friendly manner and in a spirit of helpfulness. He must go out of his way when occasion demands to explain the nature of the work and to point out its purposes. To do this he

* Paper read at the 7th Silvicultural Conference (1946), Dehra Dun, on item 6—The technique of soil erosion surveys in large and small catchments.

† *Vide Indian Forester*, 73 (2) February 1947, pp. 65-70.

must himself not only completely understand the work but he must also be an enthusiast for its objects and convinced of the possibilities of its success. The landowner and the cultivator will be the parties to any co-operative agreement and all persons have an equal right to know the programme. The surveyor must respect the rights of others both to opinions and to property. Above all he must avoid contention. An ounce of tact may be worth more than a pound of argument—however sound the argument may be—if it is not put in the right way.

A. Procedure

In the United States, the Secretary for Agriculture in 1937 established a *Committee on Soil and Erosion Surveys* to assist the office of Land Use Co-ordination in co-ordinating soil, erosion and related land use surveys particularly those carried out by the *Soil Survey Division* of the Bureau of Plant Industry and by the *Soil Conservation Service.*

The committee consists of one member from each of (1) the soil survey division (2) the soil conservation service and (3) the office of land use co-ordination.

The committee reviews all requests for conservation and soil surveys. This is to prevent duplication of field work and *to ensure that the information to be obtained meets all the requirements for basic information needed in the development of plans and programmes as a whole.* It designates an inspector for the area and approves plans for the survey. The inspector makes a preliminary examination of the area in co-operation with any interested parties and prepares a preliminary work plan and the first inspection report. This report after approval by the committee serves as a basis for the development of the survey. After completion of the survey the inspector prepares the final report, including recommendations for correlation of the soils, and presents it to the committee.

After the survey is over all data is sent to the *Soil Correlation Committee* of the Soil Survey division for consideration of correlation of soils and this is reviewed by the *Committee on Soil and Erosion Surveys.*

The data consists of (1) an accurate map as made by the inspector (2) a complete description of all features mapped (3) the original field sheets (4) the complete report (5) a collection of soil samples and (6) tables of land use according to use capability.

The *Committee on Soil and Erosion Surveys* finally approves the classification, correlation and nomenclature of all physical features mapped and submits its findings to the State or agency who asked for the survey. After approval by these agencies a report including the recommendations is sent to the office of Land Use Co-ordination for publication and to all departments or agencies connected with the survey.

B. General Scheme of the Survey

Kind of survey. (a) *Detailed surveys* are those in which features are examined at close intervals and mapped in detail. They are intended for intensive planning on individual farms or small units.

(b) *Reconnaissance surveys* are those in which features are examined at wide intervals and are not mapped in great detail. They are intended for extensive planning or over-all planning in large areas such as a district, state or large watershed unit.

Mapping should be carried out with no more detail than is absolutely necessary for land use planning. In most pasture or forest areas surveys only a little more detailed than reconnaissance surveys usually furnish all the information required. On most farm lands detailed surveys are necessary.

Maps used are (a) air photos for detailed surveys (b) topographical sheets for reconnaissance surveys (topographical sheets of sufficient scale for detailed surveys usually do not exist) (*c*) plane table maps are made when other suitable maps are not available.

Scales. (a) *Detailed survey maps* are usually 4 inches to 1 mile. Sometimes 8 inches or 12 inches to the mile may be necessary.

(b) *Reconnaissance survey maps* are usually 1 inch to 1 mile. In detailed reconnaissance surveys the parts that require detailed information are mapped on a 4-inch scale while the whole is on a 1 inch map.

Sedimentation survey.—In the case of watersheds where a reservoir survey has been made the erosion survey should be combined with a sedimentation survey in which an attempt is

made to estimate the volume of soil lost as shown by the erosion survey and to account for it as completely as possible by estimating the volume of colluvial deposits, flood plain deposits, deposits in the reservoir and suspended material carried past the reservoir.

Method of recording data on the maps.—Every survey will show (1) the physical condition of the land including soil type, slope, and character and degree of erosion, (2) present land use and (3) land use capability. (See later for details of noting these factors).

Boundaries are drawn to show all significant changes in soil types, slope groups and erosion classes.

Symbols are arranged in fractional form with the soil type symbol in the numerator and the slope and erosion symbols separated by a dash in the denominator.—A linear or vertical arrangement may be used where the size and shape of the area do not permit the fractional form.

Present land use symbols and land use capability symbols are shown independently from the composite fractional symbol that denotes the three physical factors.

A sample symbol of the physical conditions is $\frac{81\ b}{6\text{-}2\ (8)}$ which is interpreted as follows :—
(See later for symbol details) 81, Cecil fine sandy loam ; b, 4 to 6 inches of top soil remaining ; 6, dominant slope of 6% ; 2, loss of 25 to 75% of top soil, and (8) frequent gullies that cannot be crossed with tillage implements.

Reports. The results of surveys must be made available to agricultural workers, farmers and other interested persons through published reports and maps. Reports must be well written, comprehensive and authoritative. Reports will be based largely not only on the observations made during the survey but also on information and opinions derived from local sources, published and unpublished data collected from any available source, and particularly census and weather data. Suggested headings are :—

REPORT

Erosion and related land use conditions in the X X X watershed.

(1) Introduction.

(2) Description of the area.

(*a*) Location, physiography, relief, elevation, drainage, vegetation.

(*b*) Population, cities, towns, villages, transport, markets, industries.

(3) Climate—temperature, precipitation, evaporation, winds.

(4) Agriculture.

(*a*) Settlement, cropping system, present crops.

(*b*) Size of farms, labour, tenure, farm equipment.

(*c*) Agricultural industries.

(*d*) Practices affecting soil conservation and soil improvement.

(5) The conservation survey.

(*a*) Methods and definitions.
(*b*) General erosion conditions.
(*c*) Soils.
(*d*) Slope classes.
(*e*) Present land use.
(*f*) Relation of erosion to other factors.

(6) Sedimentation and soil erosion—a brief summary of the sedimentation survey with mention of applicable data from the conservation survey.

(7) Significance of physical land factors in erosion control practices.

(*a*) Land suitable for crops on basis of conservation survey.

(*b*) Use of the conservation survey in planning erosion control practices.

(8) Any further relevant information.

Field notes and background information. Each surveyor must keep detailed day to day field notes which form the background of the whole problem of the survey. It should be remembered that the final draft of the report can never be any better than the information contained in these field notes.

C. Details to be recorded

Every erosion problem is a local problem and hence the details required will be local and will vary for different localities. The following paragraphs give a list of the data that may be required, together with details of some individual items. It must be remembered that the actual details and the intensity of degree to which they are to be recorded must be decided in the merits of each area and *they must be decided before the survey starts.* For comparison with the

general details listed here, please see the description by Dr. Gorrie in a separate paper of the actual details used in an Indian survey in the Punjab.

SOILS are mapped by series and types which are differentiated on the basis of their characters. Soil properties such as fertility, permeability, water holding capacity, erodibility, and ease of cultivation help to determine their productivities. Soil types vary very greatly and proper utilisation of the land is governed within limits of sound practice by the inherent capacity of the soil to produce. Soil profiles may be destroyed by erosion and the completion of an erosion stage may obliterate an established soil type, creating conditions under which new types may be developed. *When soils are mapped they must be classified as they exist.* For example a sandy loam is changed to a clay loam when the sandy loam surface is removed by erosion and the clay loam subsoil exposed. A silt loam is changed to a sandy loam by the addition of sand by erosion from sandy areas.

SLOPE is a most important factor to record. Under natural cover a definite relation exists between slope and profile development and every soil has a characteristic range of slope. This range is often broad enough to include several recognisable degrees of behaviour with regard to erosion *i.e.* (1) under which there is little or no danger of water erosion where cultivation is practised or where vegetation affords protective cover, (2) within which erosion can be controlled on cultivated land or where vegetation affords partial protection if adequate precautions are taken and (3) above which permanent cover is required because of susceptibility to erosion. One usually requires at least 2 slope groups under (2) and two or more groups under (3). These limits vary greatly with different soils and climates. *A suitable set of slope groups for each important soil or group of soils must be decided on before the survey.*

Slope groups are designated by capital letters starting with A to represent nearly level areas.

A—Typical groups for an open porous soil might be :—

A. Less than 5 per cent.
B. 5 to 9 per cent.
C. 9 to 15 per cent.
D. 15 to 20 per cent.
E. 20 per cent and over.

EROSION is a geological process that removes or wears away soils and geological material from the land surface through the action of natural agencies, usually wind, water and gravitational creep.

NORMAL (GEOLOGICAL) EROSION is that characteristic of the land surface in its natural environment undisturbed by human activity *e.g.* as under the protective cover of the natural vegetation.

ACCELERATED EROSION is the erosion of soil or soil material over and above normal erosion, brought about by changes in the natural cover or ground conditions. It includes the changes resulting from human activity and those caused by lightning or rodent invasion.

Water erosion is designated by numerical symbols and wind erosion by letters.

Normal (geological) erosion.

O. No apparent erosion.

W. Normal erosion (active).

Ws Normal sheet erosion.
Wg Normal sheet and gully erosion.
Ww Normal wind erosion.

Accelerated erosion

Water erosion.

Two results of erosion by water are distinguished (1) removals or erosion proper and (2) accumulations resulting from removals from some other area.

Sheet erosion (symbols).

1. Less than 25 percent of the top soil removed.
2. 25 to 75 per cent top soil removed.
3. 75 per cent or more of top soil removed or all the topsoil and less than 25 per cent of the subsoil removed.
4. All the top soil and 25 to 75 per cent of the subsoil removed.
5. All the top soil and 75 percent or more of the subsoil removed, parent material may be eroded.
6. This symbol is reserved for conditions of local significance such as slips or land slides.

Gully erosion (symbols)

7. Occasional gullies: more than 100 ft. apart.

8. Frequent gullies: occurring less than 100 ft. apart but including less than 75 per cent of the area.

9. Very frequent or large gullies: an intricate network of gullies, or a single gully big enough to be separately mapped or more than 75 per cent of the area gullied.

Depth of gullies:— 3 classes.

7, 8 or 9. Shallow gullies which can be crossed with tillage implements but which would not be obliterated by normal cultivation.

(7), (8) or (9). Deep gullies: not crossable with tillage implements and which have penetrated the subsoil.

7V, 8V or 9V. Deep gullies which have penetrated into parent material.

Accumulations will be indicated by the symbol + if less than 12 inches in depth. Deposits deeper than 12 inches may be indicated by numerical symbols followed by +.

Wind erosion.

Two types of wind erosion will be recognised (1) removals and (2) accumulations.

Removals.

P. Less than 25 percent of the topsoil removed.

R. 25 to 75 percent of the topsoil removed.

S. 75 percent or more of the topsoil removed or all the topsoil and less than 25 per cent of the subsoil removed.

T. All the topsoil and 25 to 75 per cent of the subsoil removed.

U. All the top soil and 75 per cent or more of the subsoil removed, parent material may be eroded.

Accumulations.

F. Shallow accumulations less than 6 inches, either level or in hummocks.

H. Moderate accumulations, level, 6 to 12 inches.

K. Moderate accumulations, hummocky, 6 to 12 inches.

L. Severe accumulations, 12 to 36 inches.

M. Small dunes, 36 to 72 inches high.

N. Large dunes, 72 inches or more high.

The proportion of the area covered by accumulations may be indicated by following the class letter with the numeral 1 to indicate less than one-third of the area affected, 2 to indicate one to two-thirds of the area affected, or 3 to indicate more than two-thirds of the area affected.

Stream erosion.—Removals caused by streams in floods may be shown by following a numerical symbol *e.g.* 1—might mean a removal of less than 6 inches, etc.

Stabilized erosion.—May be indicated by overscoring the appropriate symbols as $\overline{7}$ or $\overline{R}$ if it is evident that a plant cover has recently stopped accelerated erosion and re-established normal erosion.

Erosion classes and groups.—The above symbols should be used either singly or in combination as required to express the type and degree of erosion. The erosion classes to be mapped must be decided beforehand and listed in the plan. Groups of erosion classes should therefore be established to express slight, moderate, severe, or very severe erosion as well as no erosion, and recent alluvial or colluvial deposits.

Mapping Present Land Use

Four major land use classes and a miscellaneous class are recognised.

L. *Cropland*—all land under crops or fallow, orchards, hay meadows. Specific crops may be indicated by L_1, L_2, etc.

X. *Idle land*—having no vegetation or maintaining plant growth of little or no economic or agricultural value. Subdivisions might be :—

X_1—formerly cultivated, available for future agricultural use.

X_2—formerly cultivated, not available for future agricultural use, etc.

P. *Pasture or range*—grazing land or range other than pastured woodland.

F. *Woodland*—land more than 40 per cent woodland. This may be subdivided to show type and condition.

H. *Miscellaneous*—such as urban areas, villages, large farmyards, golf courses, etc.

Mapping Land according to Use Capability

Use of soil conservation surveys in the development of soil and moisture conservation programmes has demonstrated the need for interpretation by means of a simple grouping of the complex factors surveyed. Such a grouping can be readily used as a physical basis for planning broad programmes of land use adjustment. Classes of land according to use capability are to be developed for each surveyed area to meet these needs.

These classes indicate *the most intensive tillage than can be practised safely with permanent maintenance of the soil* or in regions where cultivation is not practised, the most intensive utilisation for grazing or forestry that is consistent with the preservation of the soil and its plant cover.

Classes of land according to use capability in arable regions.

I. Suitable for cultivation without special practices.

II. Suitable for cultivation with simple practices.

III. Suitable for cultivation with complex or intensive practices.

IV. Not suitable for continuous cultivation.
V. Not suitable for cultivation.

Classes of land according to use capability in grazing regions.

VI. Land that can be utilized effectively for permanent grazing without special measures to control soil erosion.

VII. Land that can be permanently grazed through the use of good range management and measures to conserve rainfall and control soil erosion.

VIII. Land that can be used for permanent grazing under very strict range management (strict control of grazing incidence, rotational grazing, and careful distribution, etc.).

IX. Land that cannot be used for grazing such as barren tracts, deserts, inaccessibly steep areas, etc.

A table for determining the classes of land according to use capability should be prepared for each survey. This table should be prepared *jointly* by *all* the technicians (such as agriculture, forestry, animal husbandry officers, etc.) and approved by the inspector and by the regional conservator.

D. Range, Grazing or Pasture Serveys

In surveys where grazing or pasture is one of the main objects it is necessary to differentiate the forage types. In the U. S. A. 18 forage types are recognised in such surveys and these may be useful in helping to decide on what types require to be differentiated in India.

1. *Grassland* other than meadow. Perennial grasses predominate although weeds and browse may be present.

2. *Meadow.*

2W. Wet meadow or marsh.
2D. Dry meadow or flood plain.

3. *Perennial forbs.* (Weeds other than desert weeds).

4. *Sagebrush.* (*Artemisia* spp. and *Chrysothamnus* spp.).

5. *Browse-shrub* (*e.g.* bitterbrush, willows, manzanita, chaparral).

6. *Conifer.* Open coniferous pasture. Sub types according to species.

7. *Waste.*—Dense timber and brush with no grazing value. Large areas of very sparse forage.

8. *Barren.*—Areas of no vegetation—saline flats, active sand dunes, shale, rock slides, lava flows etc. *Note*—This does *not* include areas denuded by overgrazing which can be reclaimed.

9. *Pinon-juniper.*

10. *Broadleaf trees.*—All pasture in open deciduous timber. Sub types according to species.

11. *Cresote.* (*Covillea spp.*).

12. *Mesquite* (*Prosopis* spp.).

13. *Saltbush* (*Atriplex* spp.).

14. *Greasewood* (*Sarcobatus* spp.).

15. *Winterfat.* (*Eurotia* spp.).

16. *Desert shrub.* (*Coleogyne* spp., *Simmondsia* spp., *Acacia* spp., *Kochia* spp., *Grayia* spp., *Teradymia*, spp. etc.).

17. *Half shrub.* (*Aplopappus* spp., *Gutierrezia* spp., *Artemisia* spp. and *Eriogonum* spp.).

18. *Annuals* (weed or grasses).

Since writing the above paper on this subject a new publication has come to hand and I commend it to the attention of the conference. It is :—

JACKS, G. V. 1946. *Land classification for land use planning.* Imp. Bur. of Soil Sci. Tech. Comm. 43.

In particular it differentiates between soil surveys and land surveys and it shows how the U. S. soil survey has in fact developed into a combination of a soil survey proper and a land type inventory.

In my paper I stressed the great need for a well-written, comprehensive and authentative report to accompany the maps and field data and gave a very condensed list of the probable headings of such a report.

We are continually being asked for suitable headings for such reports and I have been asked for much greater detail than was given in my paper.

I therefore reproduce the outline of a U. S. soil survey report as given by JACKS (1946) as an appendix to his publication and reproduced from KELLOG, C.E. 1937. Soil survey manual. U.S.D.A. Misc. pub. 274.

"In order to achieve some uniformity in the treatment and arrangement of subject-matter in the report, especially for the convenience of those using large numbers of these reports, the outline which follows has been prepared. This outline cannot be followed blindly, as each area has its own particular features and problems requiring emphasis, and certain sections, given only broad headings must be carefully organized in subdivisions.

General Arrangement of Material in the Soil Survey Report

1. *Description of the area surveyed.*

(A) *Location and extent of the area.*

(1) General location within the State or Territory.

(2) Distance of country seat or principal town from one or more important places.

(3) Size of area in square miles.

(B) *Physiography.*

(1) Mention of the physiographic division of the United States in which the area is located.

(2) General description of the physiography and geology of the area.

(C) *Relief.*

(1) Discussion of any modification of the physiographic surface by natural dissection.

(2) Sketch map of relief areas if such a sketch is of material assistance to the discussion.

(D) *Elevation.*

(1) General elevation of the area and ranges in elevation.

(2) Altitude of some of the main topographic features.

(3) Altitude of towns or other known points. (Cite authority for data).

(E) *Vegetation.*

(1) General but brief discussion of the vegetation, including especially the original and present forests, grasses, or shrubs. (Ordinarily there should be no detailed description of species unless this is important where many comparatively uncommon plants are mentioned. The common names should be used, but a glossary of botanical names should be given, especially where noncrop plants need to be discussed at length).

(F) *Organisation and population of the county.*

(1) Date of settlement.

(2) Important historical data.

(3) Source and distribution of the population.

(4) Nationality of the settlers. (To be supported by census data).

(G) *County seat and principal towns.*

(1) Name of county seat.

(2) Principal towns and their relation to the agriculture of the area.

(H) *Transportation, markets, and other cultural features.*

(1) Railroads and highways and the service rendered by them.

(2) Any service rendered by steamship lines.

(3) The disposition and marketing of farm products.

(4) Conditions of public roads.

(5) Schools, churches, telephones, and other features relating to rural culture and social life.

(I) *Industries.*

(1) Important non-agricultural manufacturing industries mining, and other industries affecting the area should be mentioned and any relationship these have to the agriculture of the area noted. (The plants engaged in processing agricultural products, such as flour mills and cheese factories, are discussed under II (3).

2. *Climate.*

(1) General type, that is, oceanic, continental, etc.

(2) Variations among seasons.

(3) Distribution of rainfall during the growing season.

(4) Influence of physiography and bodies of water on climate in different parts of the area.

(5) Climate as a factor in the production of special crops.

(6) Discussion on value of the data on average dates of frost and average frost-tree periods.

(7) Discussion on value of data on average annual means for precipitation.

(8) Conditions, favourable or unfavourable, for farm work.

(9) Tables from Weather Bureau of temperature, precipitation and frosts.

(10) Discussion of unusual weather conditions, such as winds, storms and hail.

3. *Agricultural history and statistics.*

(A) *Early agricultural development of the area.*

(B) *Important changes that have taken place in the use of the land since settlement.*

(C) *Census data on the agriculture of the area as far back as available and up to and including latest census report.*

(D) *Present condition of agriculture.*

(1) Use of fertilizers, lime, and other amendments.

(a) Amount and cost.

(b) Kind of fertilizers used.

(2) Labor.

(a) Kind and availability of labor. (Do not discuss the specific wages paid in different farm operations as conditions change from year to year).

(3) Size of farms.

(a) General range in the size of farms and the size of the average farm. (To be checked by census data).

(b) Any trends toward change in size of farms and the reasons for such change.

(4) Tenure of farms.

(a) Percentage of farms operated by the owners and by tenants.

(b) Systems of rental, such as cash rent, share of crop, or other.

4. *Soil survey methods and definitions.*

(1) Description of methods used in mapping soils.

(2) Definition of terms used in the description and classification of soils.

5. *Soils and crops.*

(1) General characteristics of the soils of the area.

(2) Systems of agriculture practised.

(3) Relationship between soils and agriculture.

(4) Grouping of soils on the basis of capability for use.

(5) Brief description of each group.

(a) Agronomic relationships.

(b) Characteristics common to soils in the group that determine use.

(c) The names of series in the group and the characteristics of the types of the series brought into this group.

(d) Description of each type and phase of the group, including all the following features, if applicable.

1. Describe each horizon as to:—

a. Colour.

b. Texture.

c. Structure.

d. Consistence.

e. Thickness.

f. Reaction.

g. Content of organic matter.

h. Stoniness.

i. Root penetration.

j. Salt or alkali.

2. Important variations within the type.

3. Location and extent of soil.

a. General location of the larger areas and definite location of areas of minor types.

b. Estimate in square miles of areas of each type.

4. Relief.

5. Geologic origin of parent material.

6. Drainage (external and internal).

7. Native vegetation, if important.

8. Uses to which soil is put and crop yields woven in with capabilities of soil. Approximate acreage in different crops.

9. Management of the soil. Systems of management compared with those of area as a whole. Susceptibility to erosion or deterioration from other causes under wrong management.

10. Methods of drainage or irrigation.

11. Water supply if related to soil type.

6. *Land uses and agricultural methods.*

(A) *Capabilities of soils for use.*

(1) Crops, (2) native pasture, (3) forests.

(2) Successful and improved methods of management as demonstrated within the area.

(3) Results obtained by experiment on soil types or closely related types, including:—

(a) Use of various fertilizers, lime or other chemical treatments.

(b) Rotations.

(c) Farm implements.

(d) Prevention of erosion.

(e) Tillage.

(f) Drainage.

(g) Varieties of plants.

(h) Plant diseases, insect pests, and noxious weeds.

(This discussion should be specific in respect to the separate soils).

7. *Drainage, irrigation, or alkali amelioration* (not always necessary). (Indicate exact meaning of the term "alkali" in each particular report).

8. *Productivity ratings.*

(Instructions on this chapter will be supplied in each instance).

9. *Morphology and genesis of soils.*

(A) Location of the area with reference to the great soil groups.

(B) Parent materials.

(C) Factors of environment influencing soil development.

(D) Description of normal regional profile and a few of the more important variations.

(E) Character of intrazonal and zonal soils.

10. *Summary.*

(A) *Brief discussion of area and its agriculture.*

(B) *Uses made of soils and reason for such use.*

(C) *General statement of the character of the soils.*

(D) *Brief description of the soil groups and their relation to agriculture.*

(E) *Names of the principal soils, their characteristics, and their influence on the agriculture.*

This outline should be followed in preparing the report, unless some special individual feature of an area makes some change imperative in order to achieve a logical presentation of the material.

General

It is hoped that the above very condensed details of American experience of soil erosion surveys will help workers in India who may have to do the job for the first time to clarify their ideas before they start the work and give them an idea of the range of detail on which they may have to collect information. Many soil conservation surveys are to be carried out in the very near future and it is essential that we should make the best use of the experience of others.

WATER-LOGGING IN JABA-SUKETAR CATCHMENT IN GUJRAT SOIL CONSERVATION DIVISION

BY KHEM CHAND.

(Divisional Forest Officer, Soil Conservation Division, Gujrat).

1. *Causes.*

About 3,500 acres area in Jaba-Suketar catchment lying in flat country have been lost to cultivation through water-logging caused by cumulative rise in the subsoil water-table as a result of seepage from torrents having no outfall for small quantities of water, stagnant rain-water and mainly from the Upper Jehlum canal running in embankment.

2. *Theory.*

Water-logging is injurious to the healthy growth of plant-life due to excess of water or excess of salts (*kallar*) brought up by capillary action due to nearness of subsoil water-table below. The Irrigation Research Institute, Punjab, has investigated in its chemical section into the movements of salts in the soil profile. The Punjab alluvium consists of a shallow soil crust overlying sand of unknown depth. Sodium salts accumulate in the profile, and their movement towards the surface of the soil with a rising water-table is believed to be of considerable practical importance.

3. *Treatment.*

Results of afforestation of Pakhowal *jhil* in Daphar range during 1932-38 furnish a successful demonstration of the value of tree planting in water-logged areas (*vide plate* 4.). The species proposed are: *Eucalyptus robusta* and *rostrata* transplants and stumps, *Taxodium distichum* (an exotic timber tree) transplants, *Eugenia jambolana* transplants (on mounds) and *Salix babylonica* and *tetrasperma* (basket willow) cuttings. The willow and Eucalypts are already being planted. *Eucalyptus robusta* seed from Australia and *rostrata* seed from Chhangamanga were obtained, and nurseries of bottomless pots laid out. Creation of permanent tree-belts along the canal and the main Jaba is calculated to appreciably reduce the water-logging hazard.

After prolonged negotiations with the irrigation department, the main water-logged tract between the Upper Jhelum canal and the river were level-surveyed; and main drains were dug last year at the cost of that department, all of which have an easy outfall into the Jaba or the Jhelum river. Besides, subsidiary drains are being dug at the joint expense of this department and the *zamindars*.

Fig. I

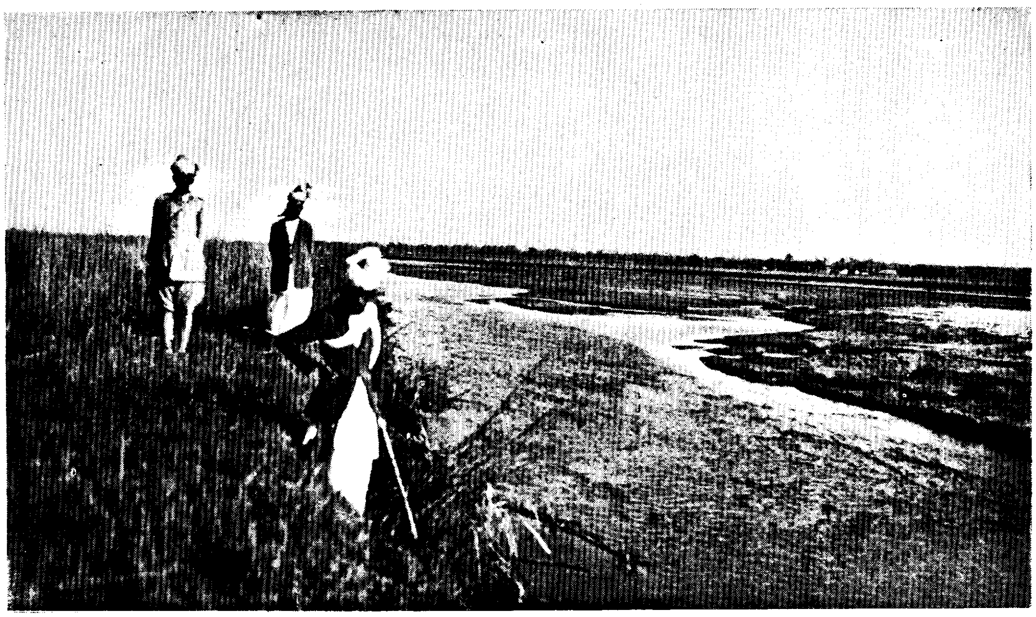

Photo: R. M. Gorrie.

Jaba kas in the lands of Bhaenagar village below the escape weir which permits it to cross the upper Jhelum canal. The whole of the village land between the canal and the river Jhelum had become water-logged and the *banjar* land now under section 38, has been provided with surface drains and is now yielding a promising *sissoo* crop.

Fig. II

Photo: R. M. Gorrie.

Four-year old *sissoo* plantation in water-logged *banjar*, Gujrat district.

BALSA WOOD

By M.B. Raizada

(*F. R. I., Dehra Dun*)

SUMMARY.—This note considers the possibilities of developing a Balsa industry in India. Information on botanical nomenclature, distribution, general characters and structure of the timber, uses, supplies and notes on cultivation, result of trials in other countries, rate of growth, yield, etc. are given.

Introduction

There was a great demand for Balsa during war time and as it is almost certain that this demand will persist even after it, it has been thought appropriate to focus attention once more on the commercial possibilities of establishing a Balsa industry in India. The present note* which was compiled in response to a number of enquiries is therefore published with the object of placing what information is available at the disposal of foresters, planters and land owners in this country who may wish to grow this remunerative timber.

Botanical nomenclature

Balsa wood is the timber of the tree *Ochroma lagopus* Sw. (Bombacaceae). The word 'Ochroma' is derived from the Greek word for paleness (especially pale yellowishness) and refers to the colour of the flowers, leaves and hair with seeds. The specific name '*lagopus*' refers to the resemblance of the long, hairy fruit to a rabbit's foot.

Up to 1919 when the genus *Ochroma* was revised by W. W. Rowlee, only two species were known, viz. *O. tomentosa* Willd. which was discovered by Humbold during his expedition to the Upper Magdalena river in Colombia and *O. lagopus* Sw. Rowlee split the latter into a number of species, those distinguished being :— *O. lagopus* Sw. in the West Indies ; *O. concolor* Rowlee in Guatemala, Honduras, British Honduras, Yucatan ; *O. limonensis* Rowlee in Costa Rica, Panama, British Honduras ; *O. grandiflora* Rowlee in Ecuador ; *O. velutina* Rowlee in the Pacific coast of Central America ; *O. bicolor* Rowlee in Costa Rica, British Honduras ; *O. boliviana* Rowlee in Bolivia ; and *O. obusta* Rowlee in Colombia.

Rowlee's division of the genus has been questioned by several authors, specially Standley, Macbride, Record, Pierce and Little who contend that the species of *Ochroma* were segregated by Rowlee upon characters that are all either ontogenetic variations or ecological adaptations. They therefore propose that all the described species of Rowlee should be reduced to synonymy under the oldest valid name, *O. lagopus* Swartz. At all events, there is said to be no need to differentiate between the timbers of the several species, except for that of *O. tomentosa*. Record and Mell state that the woods of all the species are very much alike and apparently show no more variation than is usual within a species or even in various portions of a single old tree, though they state that according to Rowlee the wood of *O. velutina* is harder and heavier than that of others.

Botanical description

A tree 60 ft. high ; growth very rapid, attaining its full height in 12-14 years, and even in half that time under favourable conditions. Leaves simple, cordate, very large (4-15 in. long), long stalked, usually shallowly lobed, subentire or toothed, stellate-pubescent. Flowers 4-6 in. long, stalked, at the ends of branches. Calyx shortly 5-lobed, 3 in. long ; lobes unequal, 2 with pointed apex, 3 rounded at apex, velvety outside. Involucel of 3 bracteoles, .5–.7 in. long, very soon falling. Petals 5, 5-6 in. long, of a pale reddish or yellowish colour or even whitish. Staminal-tube shortly 5-lobed at apex, covered from the middle to the apex with adnate anthers ; anthers 1-celled, cohering, more or less spirally twisted. Ovary conical, 5-sided ; style cylindrical, 5-sided, enclosed in the tube

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*The information contained in this note was largely extracted from the ledger files of the Silviculture branch. Acknowledgments are also due to the Central Silviculturist for kindly reading over the manuscript and making several useful suggestions.

of the filaments; stigmas 5, protruding beyond the anthers, spirally twisted and furrowed, about 1 in. long. Capsule elongate, 5-valved, about 5 in. long or more, inside covered very densely with cottony hairs; at maturity the outer husk falls off, and the down expands, and looks somewhat like a hare's foot, whence the specific name. Seeds many, enveloped in silky cotton-like fibres of a pale reddish colour.

Uses of Timber

The buoyant properties of Balsa wood, also sometimes known as West Indian cork wood, and 'boisflot' were known long before the discovery of America, but it was not until the white man began to exploit the natural resources that this tree acquired importance. Transportation in the American tropics, even to this day, is largely fluvial, and it was in transportation in the form of rafts that Balsa first took its place in commerce.

It was, however, not until the world war of 1914-1918, when cork was scarce that Balsa was used out-side of its immediate range and came into prominence for many purposes where buoyancy and lightness or heat-insulating properties were required. It was then exported to the warring nations for use in life-rafts, refrigerator insulation, aeroplane steam-lining, and mines. 80,000 Balsa floats were used in the 250-mile submarine mine barrage in the North Sea. It was also used to line refrigerator trucks for military purposes in France and it is to its insulating properties there demonstrated that the timber owes most of its present commercial application. Since it has been put to a variety of uses and is now extensively employed for lifebelts, floats for fishing nets and mines, part of life boats, hydrophlane floats, stream-lining of struts and braces in aeroplanes, and heat insulation in refrigerators and packing cases for perishable foodstuff; also as packing for armor plate in battle ships, for sound proofing and as a vibration insulator for machinery. Balsa is also employed in ceilings and partitions of rooms as a sound-deadener, and under heavy machinery to prevent transmission of vibration to other parts of the building. Its other uses include pads to protect furniture in shipment, novelties, toys, sea sleds, floats, hat blocks and diaphragms for loud-speakers. Owing to its tastelessness and the absence of any injurious properties it might find its use as a material for cigarette tips in place of cork.

During the present world war it came into great prominence as a strategic material, principally in the construction of aeroplanes and for life rafts, life preservers and floats and has a bright post-war future as an insulating material. It is interesting to note that Balsa was considerably used during the war in the construction of Britain's famous 'Mosquito Bombers' which were employed with destructive results in attacking industrial and military targets in Germany and elsewhere.

A subsidiary product of the Balsa tree is the seed floss, which is used in its native country for stuffing pillows, upholstery and mattresses. The floss, however, is unsuitable for textile industry owing to its short staple.

Distribution and supplies

The tree is distributed in the American tropics from the West Indies and Southern Mexico to Bolivia and Peru in north-western South America, though more than nine-tenths of the Balsa now being lumbered comes from Ecuador.

A timber possessing such wonderful qualities naturally attracted great attention of the world as a consequence of which brisk trade soon developed for Balsa. In spite of the fact that Central America and the West Indies were the first sources of this timber, Ecuador soon surpassed them in output and now produces most of the world's supply, the bulk of the exported timber being derived from the Guayaquil region.

According to Lawrence V. Teesdale, principal industrial specialist of the forest service of the U. S. department of agriculture, [*Journ. of Forestry* XL (1943) 885], more and better Balsa is available for war purposes, due to improved grading, inspecting and seasoning and production of Balsa in Ecuador is far above the pre-war levels, for the country's output had increased from about 16,500,000 board feet in 1941 to about 24,000,000 in 1942, the anticipated output for 1943 being 36,000,000 board feet. He further adds that study by the forest service was undertaken as a part of inter-American programme of co-operation in developing hemisphere resources for war and post-war uses.

General characters and Structure of Timber

Balsa wood is remarkable first, as to its lightness, second as to its microscopic structure,

third for its heat-insulating properties, and fourth, for its elasticity. In spite of its lightness it has great structural strength, which makes it suitable for a variety of uses. In general appearance it resembles 'bass-wood' (Tilia sp.). Until recently 'Missouri cork wood' (*Leitneria floridana*) weighing about 14 pounds per cubic foot, was believed to be the lightest, but it has now been proved beyond doubt that balsa wood is much lighter, having an oven dry weight of 7.3 pounds per cubic foot. The ordinary commercial Balsa wood is however seldom perfectly dry, and, because of the moisture content, its weight varies and has been found to be between 8-14 pounds per cubic foot. Though the timber may be considerably lighter than cork, its specific gravity varies between .12–.2, the mean value being about .14; this represents the greatest known range of specific gravity for any wood. Qualities requirements for commercial Balsa are, however, exacting for only the best wood, consisting of knot-free length from the bole are accepted. The wood is white, sometimes stained with red, silky to the touch and very open. It is comparatively strong for its weight, is easy to work, provided of course, that tools are kept very sharp to prevent the fibres tearing out, has a low thermal conductivity and is very perishable, decaying as quickly as cotton fabric if left in the woods. It is liable to be severely split unless seasoned; air drying is unsatisfactory and even kiln drying requires much care to avoid splitting, and case-hardening. It is, therefore, imperative to carry out logging and milling processes as quickly as possible so as to reduce fungus damage, sap-stain, borer attack, and the development of any other physical defects to a minimum. Once the tree has been converted into timber it has to be treated to prevent decay and troubles arising from shrinkage and swelling. With this end in view special methods of impregnation with paraffin are employed. This treatment, however, is said to raise the specific gravity but little and to render the wood more readily workable.

The structure of wood is rather special. It is composed of very thin-walled cells of barrel shape which interlace with each other and contain comparatively few woody fibres; these cells are filled with air and hence derive both the extreme lightness of the wood and its property of non-conductivity of heat. Its weight when thoroughly dried is about 7.3 lbs. per cubic foot. Incidentally there are other woods lighter than Balsa viz. *Cavanillesia platanifolia* (Quipo), *Pachira barrigon*, *Leitneria floridana* (cork wood), *Alstonia spathulata* and several others [see *Trop. Woods* No. 37 (1934) 52-53], but they lack strength, and moreover are not available in sufficient size and quantity to be exploited commercially. It is not easily available in a dry condition, however, and therefore as obtained commercially it is found to weigh from about 8-13 lbs. Although it is so light it has comparatively remarkable strength and great elasticity. The cells which are parallel to the axis of the tree are made up principally of large parenchyma cells supported by few woody fibres and those which extend in a radial direction and are defined as medullary or wood rays, are broad and conspicuous. Annual growth rings are either absent or poorly visible.

Tests carried out of the wood showed its compressive strength to average 2,225 lbs. per square inch. The crushing strength, therefore appears to be very satisfactory for such a timber—about one-half the strength of white pine or spruce. The tests show the modulus of rupture to be approximately one-half that of good spruce and their uniformity clearly indicate that the timber can be relied upon both for direct compression and transverse loads. It is a very elastic material, and when the load was almost at the breaking point the load on three of the beams under test was released and the beams resumed their original shape. It is interesting to note that it is practically impossible to split the wood by driving nails through it. A plank of Balsa wood 10 ft. 8 in. between supports $5\frac{1}{2}$ in. wide and $1\frac{3}{4}$ in. thick, supported two men who together weighed 387 lbs. The maximum deflection at the centre was about 10 in.

Conduction experiments moreover show that heat transmission through Balsa wood though not much higher than through cork is considerably lower than through white pine and very considerably lower than through zinc.

Seed

As mentioned above the seed is enveloped in silky cotton-like fibres ond can be successfully cleaned of its floss by placing the uncleaned seed on a wire sieve of 1/8 in. mesh and setting fire to it The fire flashes across and the seeds drop through the meshes. There is apparently little or no damage done to the seeds; on the

contrary, the process is said to hasten germination and raise the germination percentage. The best results were obtained when the seeds were allowed to drop through into a pan of water 2 in. below the screen. The seeds are extremely light, 3,000 weighing an ounce.

Cultivation of Balsa

1. *Site requirements.*—In its native country Balsa is said to occur most frequently in the low lands and foot hills, though rarely, if ever, where the soil is affected by brackish or salt water. It has not been found at altitudes higher than 3,000 ft. In Costa Rica exploitable Balsa occurs only up to about 450 ft. elevation above sea-level. Though scattered trees occur in virgin forest, it is characteristically a tree of second-growth types, and often appears abundantly and readily where clearings have been made by natural agencies such as floods and fires or by cultivation. It can be a troublesome weed on farm land, and the best commercial stands are reported to occur in Ecuador on abandoned fields. Good drainage is essential as the trees will not stand water-logging. In addition a rich soil, high temperatures and plenty of moisture are also required. According to Greenhouse on the Hacienda Lata, in Ecuador, it was definitely established that Balsa will not grow successfully in pure stands on a slope, or survive at all where drainage was poor. No precise meteorological data are provided by the writer, but for the Hacienda Lata lands, which lie at an altitude of 100-200 ft. above the sea-level and have an alluvial clayey loam soil, it is stated that the temperature varies from 66°-95° F. and the rainfall is extremely high, especially from January-June. The Balsa habitats on the Atlantic coast of Costa Rica have a moist, hot climate, with about 118 in. rainfall, a temperature of 80°F. and no entirely rainless season.

2. *Formation of stands.*—

(i) *Site preparation.*—As Balsa is an extreme light demander, it is necessary to clear the land of all forest cover. In Costa Rica land is cleared and burnt in January and February. In Ecuador it is recommended that clearing should be started as soon as possible in the dry season, but actually not before the rains are completely over. Burning is said to be essential in all three countries, and for British Honduras and Ecuador an intensive burn of all slash is advocated. In British Honduras experiments carried out on unburnt land, though giving promising reproduction, all failed; in the absence of burning the seedlings did not flourish beyond a height of 1.5-2 in., except in prepared nursery beds. Burning stimulates the germination of Balsa and favours its development against that of other second-growth species.

(ii) *Planting.*—In Costa Rica planting was the method used, at least prior to 1928 in so far as information is available for this country. Plants were spaced 20×20 (presumeably inches) as wider spacing was said to result in branchy and therefore knotty trees and close spacing to produce spindly ones. The young plants are, however, very delicate and fragile and experience both in British Honduras and Ecuador was against this method. Planting was abandoned on the Hacienda Lata, Ecuador after failure of all transplanted stock, whether it was put in the ordinary manner or grown in and put out complete with special bamboo pots. For British Honduras it is said that direct sowing is the only practicable method of large-scale regeneration, though it had, no doubt more success here than in Ecuador, as transplanted stock is stated to have shown slightly better growth at the end of 5 years than natural regeneration. Both in British Honduras and Ecuador, however, artificial regeneration is avoided whenever possible.

(iii) *Direct sowing.*—Sowing at stake was tried with partial success in Ecuador, but it was too expensive and resulted in overcrowded patches of mainly spindly trees that were uprooted by the first strong wind; the few outside trees that were sturdier were crooked and branchy owing to improper shading. Direct sowing has been abandoned except for filling blanks. In British Honduras experiments to date have been confined to sowing seed after clearing, with or without burning before sowing, but results obtained with natural regeneration appear to indicate that the correct method is to clear the land, broadcast the seed, and then burn. Patch burning followed by sowing has not been very successful, possibly on account of the side shade from the fast-growing huamil (second-growth vegetation) around the patches.

(iv) *Natural regeneration.*—This appears to be the preferred method in British Honduras and Ecuador. Balsa produces abundant seed and the seed floss ensures efficient wind

dispersal. Stevenson states that the seed can lie dormant in or on the soil for at least $3\frac{1}{2}$ months under second growth and responds at once by germinating when the growth is cut and burnt. Greenhouse states that the seed must receive direct sunlight in order to germinate, that he has seen seeds germinate and grow after they have been kept for 7 years without special care, and that owing to this capacity for dormancy seed accumulates in the jungle soil in vast numbers and plentiful reproduction is thus assured. (Incidentally it is worth while to put on record that tests at the Forest Research Institute, Dehra Dun, have shown that the seed of this species from dated specimens in the silvicultural museum were soaked in water for 24 hours and sown in sand with 80 per cent success. These seeds were 24 years old and were kept in ordinary glass stoppered bottles). *Greenhouse's recommendation* is that site clearance should begin early in the dry season so that the seedlings will be at least 3 ft. high (30-45 days) before the first rains, thus avoiding damping off, and that all Balsa trees on the site should be left for seed dispersal, together with an occasional timber tree (about 2 per acre) to serve as spar trees for cable logging. Stevenson says that Balsa gives excellent natural regeneration following burning either at the time of seeding (late April or early May in British Honduras) or up to $3\frac{1}{2}$ months after and possibly longer.

3. *Tending operations.*

The essential point to remember in tending is to guard against damage to the extremely fragile seedlings. Until the seedlings are 6 months old and about $1\frac{1}{2}$ in. in diameter they are said to be little more than pith and cortex and even slight injuries often cause death. They are damaged by wind, insects and disease, but natural regeneration is often so copious that sufficient trees survive by sheer weight of numbers and the chief cause of damage is the negligent workman. Even older trees will develop hard wood and thus lose their commercial market value after slight wounding.

(i) *Weeding.*—In the Costa Rica planting it was found necessary to clear the bush round the young plants up to 2 years or so, when they outstripped the 'weeds and vines'. According to Greenhouse, Balsa is comparatively slow growing and shade-tolerant in the first 3-4 months, but as the rate of growth increases, at 3-6 months of age, the seedlings become intolerant and the stand should be weeded and all but the best Balsa plant removed, leaving the crop trees about 4 ft. apart. Broadcast sowing of blanks can be combined with the weeding operation. Stevenson is of opinion that with dense regeneration no cleaning is likely to be needed, and has seen small acres of uncleaned natural vegetation where Balsa has established itself to the exclusion of all other species.

(ii) *Thinning.*—Greenhouse recommends that after this combined weeding and spacing operation the land should be left untouched until maturity. Stevenson, probably on account of different weeding practice, thinks that thinnings would be required after the first year to prevent over-crowding and the development of tall spindly stems.

4. *Rate of growth, exploitable age and yield.*

Information on growth and yield is rather scanty and shows divergence of opinion, though it is clear that early growth is very rapid. Greenhouse states that at 6 months of age the tree may be 10-12 ft. high and about $1\frac{1}{2}$ in. in diameter and that 1-year old trees may be over 15 ft. high and $2\text{-}2\frac{1}{2}$ in. in diameter. Stevenson puts the height at about 10 ft. at the end of the first year and records that in 5 years some transplanted stock had reached a mean girth of 38 in. and had an average clear bole of 12 ft. In Costa Rica the tree may attain a diameter of 25-30 in. in 5-6 years and show an average increase in thickness of 5-6 in. per year. At 5-6 years the height may be 50-65 ft. Maximum size may be reached in 10 years but wood of this age would be worthless commercially, since lightness is essential, and as the tree ages the wood loses its porous property. The Balsa of commerce is for the most part obtained from trees of rapid growth and from trees of 4-6 years. Greenhouse, however, states that trees reach exploitable size in about 10 years, being then 60-90 ft. high and having a diameter above the butt swelling of 30-45 in. After 8 years of age they develop a light pink heartwood, which is not a serious defect, but at 12-15 years the heartwood becomes water-soaked and doty, the rate of growth declines, and the wood grown from then onwards is generally very hard. Of these it is said that the yield varies greatly; merchantable timber to the extent of 5,000 bd. ft. per acre would be considered an especially

fine, 2,500 ft. per acre would be considered a fair average, while many Costa Rica plantations have failed to yield over 1200 ft.

Trials of Balsa in other countries

1. *Java.*—Balsa has been introduced into Java and is reported to be making phenomenal growth. Data from experimental sample plots are as follows:—Height increment about 26 ft. in the first year, 16 ft. annually in the third to fifth, and 6½ ft. annually from sixth to tenth years; a mean stand height of 98 ft. is reached in 7 years. Mean diameters of 12 in. is reached at 6 and 20 in. in approximately 17 years. Basal area per acre is about 109 sq. ft. at 7 years. The number of stems per acre drops from about 500 at the beginning to 300 at two years and 140 at five years. A four years old plantation had a timber volume of 13,700 bd. ft. per acre (after thinning) and the volume at ten and fifteen years is about 35,700 and 44,600 bd. ft. per acre respectively. The great difference between these and the Costa Rica figures is probably due to the enormous waste in the forest and at the mills under commercial conditions in the latter country.

2. *Malaya.*—Attempts have twice been made to introduce, by seed, the tree into Singapore, but have failed. It is, however, likely to succeed in Penang but apparently no trials have so far been made to introduce it there.

3. *British North Borneo.*—An experimental plantation raised from Guatemala seed is reported to have reached a height of 34 ft. at 7 years from the date of planting, 35 ft. at 8 years (after thinning) and 39.6 ft. with a mean diameter of 11.3 in. at the end of 9 years.

4. *South Africa.*—Troup reports that the growth of a few trees introduced in 1920 on a private estate was disappointing.

5. *Formosa.*—Balsa is said to have been introduced into Formosa by the Japanese but nothing is known regarding its success or otherwise.

6. *Ceylon.*—The tree was first introduced and planted in the Royal Botanic Gardens, Peradeniya, in 1884, the original specimen surviving until 1925 when it was blown over. Small scale trials made until 1941 in the wet country from sea level to 1,000 ft. with a rainfall of 75-125 in. did not appear promising, although it is reported that the species has been raised successfully on private land. With the outbreak of the World War II and owing to urgent demands for this wood from Australia coupled with a knowledge that possibly a first-class timber can be grown here if given right-condition, interest has again revived. It is difficult to estimate from the available data what acreage there is under Balsa cultivation at the moment but Parsons reports that all garden seed-bearing trees were utilised for raising stock and by the end of June 1945 the seedlings in plant baskets disposed of by way of distribution amounted to well over 120,000 together with nearly 5 lbs. of seed (3,000 seed weigh 1 oz.) which was distributed in addition to a wide range of applicants. This, however, did not meet the demand and many orders have had to be curtailed and refused.

Observations made from a few trees growing in and outside the Botanic gardens, in normal tea and rubber land soil, show that other than a light sandy soil is detrimental to any rapid growth and therefore lightness of timber. According to Parsons, experiments with Balsa to date (Nov. 1945) certainly appear to warrant the conclusion that the required dimensions will be attained in the anticipated period of 5-6 years, the more so in that the garden river bank soil conditions are very poor in humus content.

To grow this tree to the desired requirements of height, girth and weight of wood, it is necessary to keep the tree growing at all periods of the year. To do this the best conditions are light sandy soil and a selection of site near rivers or perennial streams where the roots can force quickly and get to the water. From observations on areas in which the few existing trees are grown it is found that where the soil is deep and permeable the tree also grows well provided an ample rainfall is experienced. Hard, stony or very cabooky soil restricts the free growth necessary to produce light wood and should be avoided. It is noted, therefore that the tree can be grown and fine specimens obtained in other than river-side conditions but that near water is preferable in that it ensures a permanent water supply which the plant seems to need for the particular purpose of producing light wood. The elevation at which the tree grows best is from sea-level to 2,000 feet in the wet zones where the two monsoons are experienced. Approximately 100 inches per year of rainfall seems to be the requirements in the south west zones. The

trees and seedlings grow exceedingly well at Peradeniya along the river side, the largest tree attaining a basal girth of 9 ft., whilst 100 seedlings planted in similar conditions in October 1941 had reached a height of 16 ft. in 8 months from planting. On the other hand trees and seedlings planted on garden hill-side on cabooky hard ground are, age for age, little more than half the size of the river side plants. The tree will grow at higher elevations but growth is slower, and with slow growth there is the tendency to produce harder and heavier wood than requirements demand. It is not known how this tree thrives in the dry zone area, but planted beside perennial streams it might do well.

When planting the seedlings, holes up to 3 feet cube should be dug to give them a good start, and 3 or 4 baskets of manure mixed with the soil when refilling. Planting distances can be as close as 10 ft. × 10 ft. (435 to acre), or 12 ft. × 12 ft. (302 to acre) but 15 ft. × 15 ft. (193 to acre) proved to be the best and most profitable in the end. The object, of course, is to get them up straight with as few branches as possible to avoid knots occurring in the wood. It is suggested that narrow belts along streams and rivers, planted thickly, would be better than a plantation in bulk. For a time after planting of the seedlings the young leaves are apt to be attacked and severely eaten by insects, so that regular sprays twice a week of a solution of lead arsenate (1 oz. of Arsenate lead, 2 gallons of water) should be given. After three months the need for spraying is eliminated.

Catch crops in this close planting would not be advisable as the tree grows so rapidly and is a very greedy feeder. If wider spacing than that suggested is given, then fodder grass could be grown with little harm. (From an unpublished note dated Peradeniya the 30th May 1944.)

According to Parsons the trials made so far (1945) indicate that in the (a) poor river washed sand area at Peradeniya combined with closed planting, 10 ft. by 10 ft. growth was good for the first and second years but tailed off in the third year but (b) with larger spacing of 12 ft. by 15 ft. and in spite of poor soil conditions the required growth of 1 foot in girth per annum is maintained. At Pallekelly with spacing of 20 feet apart and in a sandy soil of good humus content the required growth of 1 foot in girth per annum is exceeded. In June 1945, the largest tree at Pallekelly (3 years and 8 months old) was in fact 4 ft. 8 in. in circumference at 3 ft. from ground. At 5 ft. circumference the trees are marketable.

7. *India.*—1. The tree is reported to have been introduced into this country as early as 1,800 and was grown in the Royal Botanic Garden, Calcutta up to 1873. It was tried in Dehra Dun in 1918 and again in 1921 and 1923 by the Forest Botanist, but the seedlings have always died late in November as soon as the night temperature falls to about 40° F.

2. In 1935 the Central Silviculturist obtained and sent a consignment of 700 seeds to Madras for trial by the provincial silviculturist. These seeds were divided into 3 lots and tried in the Nilgiris, at Begur (altitude 2,000 ft., rainfall 71 in.) and at Kannoth (altitude 500 ft. and rainfall 166 in.)

In the Nilgiris the seed was sown on the 1st August 1935. About 30 per cent. germination had occurred by the end of the month, but by the end of September all the plants were dead.

No germination was obtained at Begur.

At Kannoth 19 out of 23 seeds germinated within two weeks of sowing (3-8-1935). A layer of fine roadside sand was spread over the nursery beds, and a shade was kept over the bed from the day of sowing.

Half the seedlings were killed by insects and other causes during the first six months, but the remainder survived and averaged 12-15 ft. high at 2 years old. At this age some were killed by a collar borer and the others died through 'sun-scorch', which caused splitting of the stem in the hot weather.

Two plants, which had their stems wrapped in regularly moistened cloths escaped this sun-crack. Only one of these plants still survives (May 1942). It is now 6½ years old and measures about 50 ft. high and 41 inches girth at 4 ft. 6 in. (It is, however, not stated whether or not this plant has started bearing flowers and fruits.)

3. The Forest Botanist obtained another small consignment of Balsa seed (through the Atkine Institution of the Arnold Arboretum) in 1940. This seed was sent to Bengal and Madras for trials.

Bengal reports that no germination was obtained at Sukna and Moraghat, 3 seeds

germinated at Hazarikhel (Chittagong) but subsequently they all died.

Madras tried the seed at the following places, with the result shown.

"Through the Forest Botanist, Dehra Dun, a small quantity of seed was obtained in January 1940 free of cost and the result of sowing is tabulated below:--

Place of trial.	Date of sowing.	No. of seed sown.	No. germinated.	Survival after one season at the end of June 1941.	Average height of plants.	Condition of plants.
1. Chandon-nathode. (altitude 2,500 ft. rainfall 162 in.)	28-1-40	786	54	21	7 ft. 6 in.	Seedlings do not appear healthy.
2. Kannoth, (altitude 500 ft. rainfall 166 in.)	28-1-40	780	Nil	Nil	..	..
3. Begur, (altitude 2,000 ft. rainfall 71 in.)	1-2-40	848	6	1	3 ft. 6 in.	Growing vigorously.

4. *Ochroma lagopus*. Is obviously a very tricky plant to grow, but it is worth persevering with as we have areas with a suitable climate in India. If once we can get a few trees up to produce our own seed in good quantity, things will be greatly simplified.

Madras and Bengal are the only two provinces which are interested at present in its cultivation. It is, however, pretty certain that once things get settled again, the Andamans, Burma, Assam and Coorg will no doubt give it a trial as suitable areas for growing Balsa are perhaps available in these provinces.

It must, however, be stressed that the main considerations in so far as data are available for the successful cultivation of Balsa are a proper selection of site with a light well drained sandy soil, suitable climate conditions and proper spacing. Unless such conditions are fulfilled one must expect a slower root formation with slower growth and a resultant heavier timber. The chief points, therefore, to bear in mind in Balsa planting is that if full returns are required the trees must produce very light wood, and that this is only obtained by quick growth under favourable conditions of ample moisture, a friable and loose soil and an elevation up to 2,000 feet. It should also be well to realize that Balsa could never become a commercial proposition such as rubber or tea. Its soil requirements (of a light sandy river bank nature) restricts growth of first class wood to definite small areas. The experience gained in Ceylon indicates that strips of river and stream banks seem to offer greatest promise, and if plantations are carried inland where heavier soil is met with, growth is slower and the wood consequently is harder and heavier.

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FOREST GRAZING IN THE MEDIUM AND LOW RAINFALL BELTS OF BOMBAY PROVINCE WITH SPECIAL REFERENCE TO SATARA DISTRICT*

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Although the subject of this note is "Forest Grazing", it is in actual fact impossible to treat forest grazing as a subject by itself. We have to consider it in relation to the grazing problem as a whole and in relation to the general problem as to the best use of all land, whether it be for forest proper, pasturage, agriculture, or any other purpose.

Forest grazing is unquestionably very important and it is our business to see that it is put on to a sound footing, but as one comes to examine the problem, it becomes increasingly apparent that unless revenue waste lands and uncultivated private lands are brought into a general grazing and pasturage improvement plan, our efforts to improve the position in the forest can never be fully effectual.

We have in fact started work to improve forest grazing and it is this very work that we are doing which has brought home to us the fact that for real effect we shall have greatly to widen the scope of our work. Before, therefore, discussing what we are actually doing, it appears desirable to present a general picture of the present position with regard to the feeding of cattle.

Except near the big towns, where milch cattle are important, the ordinary villager keeps two kinds of cattle, his working cattle and his non-working cattle. Milch cattle in the villages are few and are not, as a rule, considered important as such. This neglect of milk as an important article of diet is of course, one of the main planks in the village improvement programme and a lot of work is being done to try to get the villagers to drink more milk. As matters stand at the moment, however, the villagers are not very interested in milk production or milch cattle. They are however, very interested in their working cattle, as on these depend the tilling of their fields and the carrying of their produce to market.

They are prepared to take considerable trouble to keep their working cattle in good condition. They often stall feed them, will purchase oil cake for them and are also willing

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to pay government or private owners, fees for grazing and grass cutting.

In direct antithesis to the care which they take over their working cattle is their neglect of their non-working cattle. These they keep only for manurial purposes. They get no stall feeding and are herded along the road sides, into cut fields, into private lands and forest to pick up what living they can. They are allowed to breed quite promiscuously, and the result of this semistarvation, combined with uncontrolled breeding is a race of thin undersized cattle which are of little or no use, except as rather inefficient manure producers; inefficient because the very system of allowing them to walk miles every day gleaning their food must mean that a very high proportion of the manure produced is lost and only that passed at night is generally collected.

The presence of large numbers of unfit and sickly cattle is a perpetual menace to the better and more healthy cattle, because, owing to their very weakness, their resistance to disease is lowered and they fall ready victims to the severe epidemic diseases which frequently sweep through the herds. If only these diseases would confine themselves to the non-working cattle, they would be useful in reducing the numbers of such cattle, but they invariably spread to the valuable working cattle and cause heavy losses, resulting in difficulties in cultivating the land and in transporting the produce. In the working season of 1943/44 such an epidemic of rinderpest looked at one time as if it would cause a serious reduction of war supplies of their timber in the southern circle owing to the heavy death roll amongst logging buffaloes; and even though production was maintained to the extent that the railway could transport the material, much timber was left in the jungles through the monsoon which would otherwise have come in to the depots.

Herds of Useless Cattle

From time to time this department has made efforts to get the villagers to reduce these herds of useless cattle, but here we are up against two problems; firstly the prohibition enjoined in the Hindu faith against the destruction of any cattle and secondly, the statement that these cattle are the only source of manure for the poor cultivator.

The first objection of course is insuperable as far as persuading the people to destroy badly bred and weakly cattle goes, but they will sell such cattle and it may be that the solution will lie in organising the sale of these cattle and in slaughtering them in places where religious susceptibilities will not be affected. Large numbers of cattle are of course already being slaughtered to produce beef for the classes which are able to eat it, but such slaughtering, so far has touched only the fringe of the problem in the districts; there large herds of cattle still remain. In fact, it is questionable if the finding of a good market for unwanted cattle is really a solution. In the case of goats, for example, factories for the supply of dehydrated goat meat have been started. In this province we were delighted at the idea of reducing the large overpopulation of goats in this way. But it has not worked out as we had hoped. Astonishingly high prices have been paid for goats by the dehydrating factory, so that goat owners have enthusiastically been breeding more and more goats. It seems probable that so far from there being a reduction in the goat population we are well on the way to a big increase! It seems therefore, that the finding of markets for unwanted cattle might turn out to be very much of a two edged weapon! However, cattle do not breed so quickly as goats and if markets were found, it is to be hoped that a better and better standard of cattle would be required for such markets, which would in itself reduce promiscuous breeding and neglect.

The objection that the cattle are essential for manurial purposes is quite true, although as pointed out before, the very method of casual grazing militates against the maximum quantity of manure being obtained. One would venture to say that half the number of cattle, well looked after and stall fed would produce as much or more manure than do those half starved animals which are regarded as so necessary for cultivation.

The 'manurial' argument is partially demolished by the fact that so much of the manure collected is made into dung fuel cakes in areas where wood fuel or charcoal are deficient or expensive. This however, only produces the other argument that dung cakes are the poor man's fuel and it has to be admitted that until something better can be found, these inefficient producers of manure are necessary.

The answer lies in the supply of cheap wood fuel to eliminate the necessity of wasting farmyard manure for fuel and in the increasing

use of leaf compost manures and chemical fertilisers.

We cannot hope to improve forest grazing until we can reduce and control the number of cattle grazing and we cannot do this until it can be shown that these 'non-essential' cattle are really non-essential.

Very close co-operation between the revenue, agricultural and forest departments is essential if the problem is to be solved and it appears likely that a very long period of propaganda and demonstration will be necessary, before the people will be persuaded to abandon their uneconomic habits.

Scarcity Areas

Coming now to the forest grazing problem we find that in Bombay the grazing problem is in general only acute in the areas where over-population and its consequential land hunger have driven the forests back to the hills so that the ratio of forests to agricultural land is generally very low. In areas of heavy rainfall where this has happened the problem is not usually so acute as there is a tropical luxuriance of growth which is as a rule greater than the ability of the cattle to destroy it. It is in the Deccan plateau east of the western ghats in the districts of Nasik, Ahmednagar, Poona, Satara, Sholapur, Bijapur and in parts of Dharwar and Belgaum that the problem is serious, where the rainfall is 30 inches or less. Here we find eroded and denuded hills classified as reserved forest which vary from complete barrenness to the carrying of a poor type of mixed deciduous forest. Barrenness is however, the prevailing condition, and in a journey by road from Nasik *via* Poona and Satara to Kolhapur, a distance of about 270 miles one sees range after range of hills almost completely bare of growth and carrying not even a good grass crop.

On the journey from Nasik to Poona where the road is not fully bridged the run off from the hills when it rains is so rapid that one has to be very careful not to get caught by a spate in one of the *nalas* when moving in the rainy season.

Gully erosion and *cho* formation are also seen in this area.

Of course not all the barren hills which one sees are reserved forest. Many of them are privately owned and the owners do nothing at all about them, save only to let them out for the meagre grazing which is found there. It is in fact curious to note what large areas of what is now useless land are privately owned. Presumably when they were obtained originally, they must have carried either a tree crop or good grass. Now, however, there is neither, and it is such lands as these which will have to be brought into a general grazing and pasturage improvement scheme if we are to have the maximum improvement.

Close examination of these denuded hills shows that they have generally been eroded to the point where soil, as such, can hardly be said to exist at all as it consists of *murum* of varying degrees of hardness and sometimes even the *murum* has disappeared, leaving only sheet rock. Good grasses are almost entirely absent and the prevailing grass species is the dwarf spear grass *Aristida funiculata*. Almost all private uncultivated lands are in this condition. The forest areas are often rather better and have not proceeded so far down the path of deterioration, owing to the fact that there has been an attempt to protect the tree growth where it exists at all. It may here be remarked that up to the time when a "popular" government took office, grazing fees were payable all over the province. Then in 1935 all forest grazing was made free. This of course was a further encouragement to the keeping of useless cattle and it appears likely that during the 11 years that free grazing has been in operation, deterioration in deficit grazing areas will have been more rapid. Unfortunately statistical information to prove this point is lacking, but it seems on the face of it to be a logical assumption.

The only areas where anything like good grass is to be found are in the established grass *kuran* areas. These are maintained for grass production and are either kept for grass cutting or limited grazing or sometimes both. The point however, is that there has been control which has been accepted by the villagers and there has not been a great deal of illicit grazing.

There cannot be any quick cure for the damage which has taken place in all the areas open to unrestricted grazing, but we do believe that it will be possible to have steady and continuous improvement if we can persuade the people to co-operate with us in our plans. The two main schemes which we are attempting are the 6 and 4 Pasture Rotational Grazing

Schemes in Satara district.

Six Pasture Scheme

The Six Pasture Scheme was started in 1942 as an experimental measure to see how far it would be possible to go in our improvement schemes with conditions as they are now.

The basic idea is to get part of the area closed for full improvement, to use part of it as special grazing grounds for working cattle and to have rotational grazing for non-working cattle in the remainder of the area.

For this purpose the area has been divided up into felling series, ranches and Pastures.

The unit for management is the felling series and each felling series is divided into 6 ranches, each ranch having 6 pastures. Each year one pasture in each felling series comes under complete closure and will remain closed until the next pasture in the same ranch comes up for closure. Thus it will take 6 years for one pasture in each ranch to come under closure and 36 years to work over the whole felling series.

Taking one ranch as an example, the treatment will be as follows:—

One pasture will be closed to grazing. If it contains tree growth such felling as is desirable will be done. Improvement works of contour trenching, contour ridging with stones, gully plugging and *nala* bunding will be carried out. Where contour trenching is done tree growth will be introduced. In between the contour works grass sowing and tuft planting will be done.

One pasture will be reserved for the working cattle.

Four pastures will be reserved for rotational grazing by all cattle. For this purpose the rainy season is divided into two periods, (i) from 15th June to 31st July and (ii) from 1st August to 31st October. For each of these periods two pastures will be allotted and the two grazed first in the one year will be the two grazed last in the next year.

From the 1st November until the 14th June all four pastures *plus the pasture reserved for working cattle,* will be open for general grazing.

The foregoing gives a brief idea of the lines on which the Six Pasture Scheme has been drawn up. There is no need here to go into details of the counter erosion works, afforestation and grass introduction work to be done, as these are subjects dealt with elsewhere in the agenda of the conference.

Four Pasture Scheme

In 1944/45 we started on another scheme which we call the Four Pasture Scheme. The principles are precisely the same, but in this scheme we get a longer period of closure.

Here the felling series is divided into 9 ranches and each ranch is sub-divided into 4 pastures. One pasture is closed for improvement, one allotted for working cattle and two for rotational grazing. The system of one pasture per felling series being improved each year thus gives us the same rotation of 36 years, but the closure is increased from 6 to 9 years and one-quarter of the whole area is closed as against one-sixth.

In both schemes whilst it is considered that contour work can only be successful in areas where there is full closure, it is proposed to carry out *nala* bunding and gully plugging on the lines of drainage throughout the whole area as soon as possible. This work cannot of course be fully effective until the catchment areas of the drainage system are also tackled, but it is hoped that they will be helpful in holding up some of the eroded material and in preparing beds where anti-erosive vegetation can be introduced.

The six pasture scheme deals with the comparatively small area of 7,491 acres whilst the four pasture scheme covers an area of 27,136 acres.

Whilst the above details may be of some interest, it is of course quite clear that one can juggle around with ranches and pastures to produce all sorts of variations and the only special claim we can make for these schemes is that they have the merit of simplicity. What will be of far greater interest is the way in which they are working out.

The two schemes cover areas which are rather different in character. The Six Pasture Scheme is located in Wai *taluka* just to the east of the ghats and is generally in an area of good rainfall. The Four Pasture Scheme on the contrary is well to the east of the ghats, on the ranges of hills lying to the east of the M. & S. M. Railway. Here rainfall is less and erosion and denudation have gone further

It is too early as yet to say what success we shall have for either scheme. The Six Pasture Scheme is so far being put through without serious opposition, but the period of closure is definitely too short for the proper establishment of tree growth.

It should, however, be amply sufficient for the improvement of the grass. Closure alone will often do this, provided that there are sufficient seed-bearers of good grasses still left on the ground, and with our policy of introducing good grasses we hope to be able to ensure the success of this part of the programme.

The Four Pasture Scheme giving as it does 9 years of closure is likely to give a much greater chance of success for afforestation works, though growth in these areas is so slow that even 9 years will often not be enough.

The Four Pasture Scheme has of course only just started, but here we are encountering difficulties. We have come into areas where the grazing is much poorer and the pressure on it therefore, greater. As far as we can gather the people don't much like this scheme as it closes too great an area at one time and the grazing is so poor that they want it *all* to be available *all* the time. Present indications are that we shall have to revise this scheme on the lines we have been compelled to follow in the special post-war reconstruction scheme for Satara *taluka*. Satara *taluka* is one of the *talukas* selected by Government for concentrated post-war reconstruction and improvement.

Reconstruction Plan

Each department has to produce and carry out reconstruction plans. Our plan here was to introduce rotational grazing and improvement in forest and revenue waste lands on the lines of the Four Pasture Scheme. Before doing this however, we thought that we had better find out what the villagers had to say about it. We found them very strongly apposed to rotational grazing, but very willing for special grazing areas to be reserved for working cattle. They were also willing for very small areas to be taken up for full improvement.

Thus our scheme for this *taluka* has got down to closure of small areas of about 25 to 50 acres, reservation of special areas for working cattle and no restriction over the rest of the area. Our hope is that in the small areas we are able to close that we shall be able to demonstrate the value of our work to such an extent that the villagers will themselves ask for further closure, and that we shall thus be able gradually to work them into a rotational grazing scheme.

It should not be imagined that because the villagers are unwilling to go in for rotational grazing at once that we consider that they are being unreasonable. We can very much sympathise with their point of view. The general system on which the correct incidence of grazing is calculated is 1 acre per head in the heavy rainfall areas; $1\frac{1}{2}$ to 2 acres in the medium rainfall areas and 3 acres in the low rainfall areas. When it is pointed out that in the areas under consideration the incidence of grazing often works out at about one acre per head and when it is realised that these are low rainfall areas, the alarm of the villagers at any suggestion of reducing their available grazing can be well appreciated.

That they will have to suffer before their state can be improved is, it is feared inevitable, and we are now trying to get new grazing rules sanctioned so that we shall have more control. It is not proposed here to go deeply into the new grazing rules, as a copy of these can be had if desired. The principle on which the new rules is based is that above all things we must ensure that what we call 'Essential' cattle are provided for before the 'Non-Essential'. Essential cattle are those required for the plough, for transport, other farm work and milch cattle and the number of essential cattle any one cultivator is entitled to hold has been calculated on the basis of the agricultural land held and being kept under cultivation by the farmer.

Only when the needs of the essential cattle have been met is any provision to be made for non-essential cattle and whilst it is proposed to allow grazing of essential cattle free, it is proposed to charge fees and quite high fees for non-essential cattle. Whether these proposals will go through, yet remains to be seen, but it is obvious that unless these or some similar proposals are adopted, there will be little chance of any genuine improvement. We may have our rotational grazing schemes and our *kuran* schemes but all will be quite useless if we go on with the old game of trying to get a "quart out of a pint pot". *The incidence of grazing must be reduced to an incidence that the grazing grounds can stand.* Given a reduction in the

numbers of cattle grazed we can improve the grazing and it is quite possible that with control of the uncultivated private lands as well, we could so improve the pasturage that not only could the present herds be supported, but even larger ones. But reduction of herds must come first in order to give the grazing grounds a chance to improve and only when improvement has taken place can herds be allowed to be increased.

Private Lands

This brings us to the subject of the private lands about which mention has been made before. In these areas the forests have often been driven right back to the mountains and even the foothills are privately owned. These private owners as has already been remarked, do nothing about their lands except to let them out for grazing to the villagers. The lands themselves are so eroded and barren that they cannot get much for them, but in spite of their awful condition, they are often on gentle slopes where improvement works such as contour trenching, *nala* bunding and gully plugging would have a far better chance of succeeding than on the precipitous slopes of the forest. Only if we can control such lands are we likely to meet with full success in our schemes. Work is going on to see how best we can deal with the situation which arises from the neglect of private lands. There has been considerable discussion as to whether we need a special Act, whether we can apply the Land Improvement Act or whether Chapter V of the Forest Act can be suitably modified to meet the situation. It is not proposed to consider here the pros and cons of the arguments put forward in favour of any particular method of gaining control. All that it is necessary to say is that whatever method is employed the sooner we get started on it the better.

In this note the question of sheep grazing has so far not been considered and in the operations we have started the areas allotted for sheep grazing have been omitted. It is however, a problem which has to be tackled and we are now about to start work in Sangola *taluka* of Sholapur district where the main problem is likely to be sheep grazing. In Sholapur there is of course the famous breed of *Khilar* cattle, but these well-bred cattle are generally stall fed on *kadbi* (*jowari*) (*Andropogon sorghum*) stalks and in this great *jowari* producing area there is usually a good stock of *kadbi*. In the sheep raising areas it is proposed to proceed in the first instance on the same lines as in Satara *taluka*, except that there will be no special area reserved for working cattle and all the area not under special treatment will be open for grazing.

We shall try to improve and develop grass *kuran* areas eventually working up to the stage where we can have rotational grazing for sheep as well as for cattle. We are only just beginning this work and what we do will depend very greatly on the support we can get from the public and the staff we can find to do the work.

We have at present no forest organisation in Sholapur district, as in 1908 the Sholapur forest division was abandoned and all the forests were handed over to the revenue department for management. This has generally resulted in no management, little or no protection, and an excessive disforestment policy, so that it will take some time to get things organised when we take over again as it is proposed that we shall do.

Essentials of a Pasturage Policy

Finally I should wish to emphasise the following points which I consider essential to a successful grazing and pasturage policy:—

(i) The treatment of the feeding of cattle and sheep as one problem.

(ii) The amalgamation of all grazing lands into one comprehensive scheme.

(iii) The necessity of ensuring closure by means of fencing. Mere declaration of an area as being closed is not enough. Closure will not work unless areas are literally closed. There should be wire fences with regular men patrolling to maintain and repair them. Live hedges may be used where possible, but growth is often so bad that they are not likely to come to much. We have indented for quantities of military surplus barbed wire for a start, but this is often not galvanised and so its life will be limited.

(iv) The necessity of encouraging the making of silage. We are working up this by making departmental silage pits and giving away the grass when the time comes to open them. We hope to get the villagers making them themselves soon.

(v) The necessity of encouraging the making of leaf manures as substitutes for farmyard manure.

(vi) The necessity for continual propaganda.

It will be noted that in all this note goats have not been mentioned. This is because it is felt that in an any government controlled grazing scheme no provision must be made for them. Excessive goat breeding is the final sign of a deteriorating countryside and every effort must be made to discourage their *maintenance.*

Since writing this note, I have learnt that in the United Provinces it has been found that it is preferable to have complete monsoon closure to grazing rather than the rotational closure described here. We shall hope to try out this method which would apparently mean that instead of having our rotational areas open at different times in the monsoon, we should have one area open one year all the monsoon and one area closed all the monsoon.

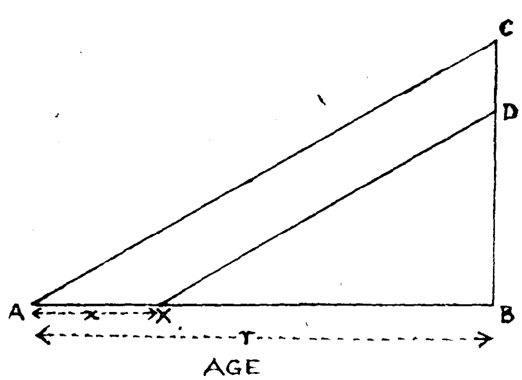
A NOTE ON SMYTHIES' MODIFICATION TO VON MANTEL'S FORMULA FOR YIELD REGULATION

By S. S. Mandal, M.Sc.

(*Student, Indian Forest College, Dehra Dun.*)

Von Mantel's formula gives the annual yeild as $y = \frac{2G}{r}$ where G is the total growing stock and r the rotation. This formula requires the complete enumeration of the total growing stock as also the complete measurement of its volume. But, in practice, neither a complete measurement of the volume nor a complete enumeration of the growing stock is feasible. Hence modifications of Von Mantel's formula have been necessary in order to meet these practical requirements.

Now let us consider the practical case when the growing stock is both enumerated down to a girth or diameter equivalent to an age X years and measured for volume to the same girth or diameter limit of utilisable timber,—which is the premises upon which Smythies has based his modification.



In the adjoining figure, let $\triangle$ ABC represent the total normal growing stock, while the growing stock actually enumerated and measured in practice is represented by $\triangle$ XBD where XD is parallel to AC. This presupposes that the volume of the small wood, *i.e.*, below the diameter limit of utilisable timber (generally 8 inches) corresponding to the age X years in a crop remains approximately constant, which fact is fairly borne out by yield tables for *sal* (*Shorea robusta*).

$$\text{Let} \quad ABC = G$$

$$\text{and} \quad XBD = V$$

Smythies' modification, which prescribes the annual yield by the formula $Y = \frac{2V}{r-x}$, is not a true modification of Von Mantel's formula, in that the consideration of the growing stock is limited to the partial volume V, which is used as such to determine the yield and not correlated to the total growing stock G. Thus, the volume represented by the portion AXDC is completely disregarded. Hence the better procedure would be first to render the total growing stock G in terms of this partial growing stock V, and then use Von Mantel's formula in its original form *e.g.* $Y = \frac{2G}{r}$

Now, $\triangle$s ABC and XBD are similar.

$\therefore$ from the properties of similar $\triangle$s, we have

$$\frac{\triangle ABC}{\triangle XBD} = \frac{AB^2}{XB^2}$$

$$\text{or, } \frac{G}{V} \quad \frac{r^2}{(r\text{-}x)^2}$$

$$\text{Whence } G = \frac{r^2V}{(r\text{-}x)^2}$$

$$\therefore \text{ annual yield } Y = \frac{2G}{r} = \frac{2r^2V}{(r\text{-}x)^2 r} = \frac{2rV}{(r\text{-}x)^2}$$

Thus the *modification* of Von Mantel's formula, under the premises employed by Smythies should read: $Y = \frac{2rV}{(r\text{-}x)^2}$

It must be mentioned that even this formula would not be wholly of correct applicability, since the age corresponding to the girth or diameter limit adopted requires to be modified by the period taken for growing from ground level to breast height. But this may not, in practice, affect results appreciably.

It should be apparent that Smythies' formula is a special case of this general formula, when x is so small compared to r that (r-x) can be approximately taken to be equal to r.

$$\text{Thus, } Y = \frac{2rV}{(r\text{-}x)\,(r\text{-}x)} = \frac{2rV}{(r\text{-}x)r} = \frac{2V}{r\text{-}x}$$

When $x = 0$, *i.e.* the total growing stock is taken into account, Von Mantel's formula is obtained in the following way:

$$Y = \frac{2rV}{(r\text{-}x)^2} = \frac{2rV}{(r\text{-}o)^2} = \frac{2V}{r} \text{ (when } V = G)$$

In this connection the following articles in the *Indian Forester* may be referred to:—

1. E. A. Smythies 1922—*Indian Forester*— 48 (12) pp. 630-631.
2. C. E. Simmons 1923—*Indian Forester*— 49 (7) pp. 393-395.
3. H. R. Blanford 1923—*Indian Forester*— 49 (9) pp. 526-527.
4. S. K. D. 1923—*Indian Forester*— 49 (9)pp. 502.

THE AFFORESTATION OF THE DRY AND DESERT AREAS OF NORTH-WEST INDIA *

BY N. G. PRING

(Conservator of forests, North-West Frontier Province)

The arid zone of north-west India stretches from the western United Provinces to the border of southern Afghanistan and Persia; and from the Siwaliks to the Arabian Sea. The Thar or Great Indian desert, and the even hotter region that lies farther west in Sind and Baluchistan, are the principal deserts, but desert or semi-desert conditions prevail over extensive areas in neighbouring provinces and states. In fact north-west India is the eastern component of a desert or arid zone which extends westwards to the Atlantic ocean. From the Thar desert one could fly to the west African coast over lands where the mean annual rainfall nowhere exceeds 10 inches and in many places falls below 5 inches. Throughout this vast region populations are dependent on irrigation for their subsistence and in north-west India irrigation is essential for the cultivation of many crops.

In regions of low mean annual rainfall, where the normal precipitation is barely sufficient to raise crops, irrigation becomes doubly necessary as an assurance against long droughts. It follows therefore that prosperity depends very largely on the flow of springs and rivers. Irrigation from local resources has been practised from ancient times; and, in many cases reached a high degree of proficiency in India. The capturing of water underground in Baluchistan and the storage of water in the Rajputana shows the greatest ingenuity. Until recent times the areas brought under irrigation assumed a very small proportion of the land, and generally speaking, the efficiency of the catchments had not been impaired. Except in the case of snow at high elevations or in high latitudes, the retention of the water supply depends mainly on the storage capacity of the ground, which is determined by the vegetation.

*Paper presented at the 7th All-India Silvicultural Conference (1946), Debra Dun on item 3—The afforestation of dry and desert areas.

The evils of disforestation or devegetation are too well known to need repetition; one may merely emphasise the fact that the ground storage capacity and therefore the vegetation cover is most important in arid regions where it is essential to preserve the maximum possible water resources.

Climate of North-West India

There is no reason to suppose that the climate of north-west India has changed within historical times. More than twenty-two centuries ago Alexander the Great lost all his transport and a large number of troops when marching through the desert of southern Baluchistan. Forced to turn inland east of Pasni, his sole enemy was the desert. The many hundreds of ancient collecting tanks and other devices for irrigating the desert along the coastal regions of northern Egypt and Libya indicate the necessity for irrigation and the fluctuations of climate in olden times. The Old Testament records severe droughts and famines, one of which caused the Israelites to migrate to Egypt. The seven lean years during their sojourn there and the seven years drought in Palestine during the life-time of Elijah were typical indications of severe droughts and hard times for farmers in the past. From ring countings in the U.S.A., Dr. A. E. Douglas showed that there was a great drought which commenced in 1276 and lasted twenty-three years. The following is an example of recent fluctuations in rainfall. At Burg el Arab, about 30 miles west of Alexandria, the annual rainfall for the period 1939-40 to 1944-45 averaged 5.3 inches. In 1940-41 it was approximately $3\frac{1}{4}$ inches and 1944-45 approximately $9\frac{3}{4}$ inches. Over regions of low rainfall similar anomalies probably occur in north-west India.

The *Climatological Atlas of India* (Eliot) issued by the Indian Meteorological Department shows that the driest and hottest region of India lies centred just north of Jacobabad. A region of less than 5 inches normal rainfall includes parts of Sind, Khairpur and Baluchistan, including the mountains east of Kallat and around Sibi. On the same rainfall map the Great Indian Desert is shown with a normal annual rainfall of between 5 inches and 10 inches, increasing to 10 inches and above on the eastern fringe. Much of Baluchistan has a mean rainfall of less than 10 inches, and the same applies to parts of the North-West Frontier Province and the south-west portion of the Punjab. It should be noted however that in many of the mountainous regions, where the rainfall is measured in the valleys, precipitation on the ranges is appreciably higher; this is certainly so in the case of places having a very low rainfall such as Gilgit and Chitral, and also of the Kurram valley where precipitation on the higher slopes of the Safed Koh may exceed 30 inches.

Perhaps the main geographical feature of the north-west arid zone is the high region in the west adjoining the Afghan and Persian arid plateaus, and the low arid region extending from the Indus valley eastwards. Most of the region west of the Indus is cut off from the south-west monsoon, though unpredictable localised thunder-storm showers, occasionally widespread and very heavy, do occur. The high arid regions benefit mainly from winter and spring precipitation whereas the eastern low arid zone receives most of the rainfall during the south-west monsoon. The northern plains receive both summer and winter rain, the greater quantity falling in the summer. Winter rains or snow and severe frosts followed by longer summer droughts and intense insolation have produced a flora in the west differing from that in the east, where most of the rain falls in July and August.

Irrigation Schemes

Within the north-west Indian arid zone the major irrigation schemes, which extend from the United Provinces to the North-West Frontier Province in the north and to the Sind desert in the south, have reduced the desert and semi-desert areas by thousands of square miles. The idea of canalizing the Himalayan rivers was first conceived by the Moghuls and development, dating from the latter half of the last century, has been one of the greatest achievement of modern times. Expert interpretation of long-term statistics will show whether this vast network of irrigation has increased the rainfall over irrigated or neighbouring areas. It certainly has modified local conditions as regards humidity, temperature and vegetation. It would be out of place to include afforestation of the areas under permanent irrigation, and the technique of irrigated plantations has been adequately dealt with elsewhere. The general effect of irrigation on the neighbouring countryside does however need consideration. Large-scale irrigation and the resulting rise in population has almost invariably led to the

spoliation of the vegetation on the nearest available uncommanded areas by overfelling and by overgrazing. In hilly country this has led to the ruination of important catchments. The Arab invaders of Baluchistan introduced a highly developed system of irrigation subsequently abandoned for no political reasons. The *Encyclopaedia Britannica* considers the most likely cause to be disforestation followed by erosion, and the usual sequence of silting, reduction of the sustained water flow, and spates. Recent reports by senior forest officers all show the urgent need for afforestation in that province. Many examples of catchment destruction could be cited. At the time of the second Afghan war the Kurram valley above Parachinar was well wooded. The Commandant of the Kurrum Militia informed the writer that he could remember the forest almost down to the base of the hills above Parachinar. The lower slopes are not completely denuded, to the detriment of the valley which is being cut up by torrent ravines. West of Peshawar the Bara Nala catchment has been almost denuded by fellings for the Peshawar market, a state of affairs that could have been avoided if fuller use had been made of canal banks, roadsides and other sites for plantations in the Peshawar vale, where watering is necessary for the first two years only to establish plantations. Throughout the hilly tracts of the arid zone there is a great deal of local irrigation, and to destroy the catchment in such areas is to destroy the goose that lays the golden eggs. The point is that if afforestation in the arid zone is to succeed, the fullest use must be made of plantations in the irrigated belts, including local and minor irrigation schemes, in order to ease the strain on the catchment regions, particularly during the first two or three decades. As reafforestation progresses, and new units come under regular management, the position will improve. Judging by the present shortage of firewood and the amount of animal droppings used as fuel, there is no fear of overproduction. One remarkable feature of recent village plantations and reserves set aside permanently for afforestation, has been the growth of grass and other herbs as the result of even a single year of closure to grazing. Management must include the growing and harvesting of hay.

Sand and Dust

In desert and very arid regions, where vegetation is sparse and the soil necessarily exposed, it is important to distinguish between sand and dust. Bagnold(1) defines the lower size-limit of sand particles as about 0.08 mm., dust particles falling below that limit. Sand grains lifted from the ground by wind rarely rise to more than two or three feet, and proceeding down wind in a series of low hops or saltations, either bounce off the ground again, or hitting other grains at rest, flick them into the air. Sand movement is restricted to a sort of creeping carpet which remains aggregated in dunes. Dust particles become airborne until such time as air movement moderates; and travelling in clouds, often at great height, they may be carried to great distances. There is a recorded instance of dust being carried from North Africa to Sweden. During the hot season, dust from the Punjab plains is sometimes carried as far as Kulu. By measurements of deposits during field research in Egypt, Oliver(2) estimated that during a turbulent dust-storm on ground stripped of the natural vegetation, deflation removed as much as one half of a ton per acre per hour. More frequent figures were in the order of one-sixth or one-eighth. The area in question was completely denuded during the African campaign and remained so for several years till the zone of hostilities moved away. The herbaceous vegetation then re-established itself during a favourable year of rainfall. *Carrichtera annua*, *Enarthrocarpus lyratus*, *Matthiola humilis*, *Centaurea glomerate* and *Trigonella stellata*, all of the more or less prostrate type, played the most conspicuous part. During the period of denudation the number of dust-storms increased enormously and declined again after revegetation. Most striking was the contrast between the mean wind velocities required to produce dust-storms over the same area when denuded and when vegetated. It is certain that deflation can be controlled by vegetation. In desert and semi-desert regions, where trees or scrub forest can grow only in a few favourable locations, the desert type of herbaceous flora plays a most important part. In the absence of experimental research it is difficult to assess the effect of

(1) BAGNOLD, R. A., 1941. The physics of blown sand and desert dunes.

(2) OLIVER, F. W., 1945. Dust-storms in Egypt. *Roy. Geograph. Soc. Jour.* July/August.

deflation in India. It would appear to be of considerable significance in the Sind-Rajputana deserts; dust-storm tracks have been plotted which started in desert west of the Indus and travelled across India to the Gangetic plains. Granted that vegetation is the best preventive of erosion by wind or water, the fact remains that desert cannot be afforested on a large scale, and during the dry hot season, a great proportion of the natural ground flora withers. Therefore while sand drift and dust storm must be expected, deflation can be greatly reduced and dunes can be stabilized by vegetation. Perhaps afforestation will produce the best results if the desert is attacked from the border line, by creeping vegetational belts, reinforced by shelter belts of trees and shrubs.

Shelterbelts

In the cultivated area of the arid zone, shelterbelts, in the form of high quickset hedges with standards, would, the writer is convinced, be of great value in checking deflation; the quick-set hedge would also reduce evaporation and would prove an asset to the farmer in other respects. After harvesting there must be a percentage of decaying vegetable and animal matter, valuable as manure, and which being light is most likely to be blown away before the time of ploughing. In the hills, strong winds blow up the valley or down the valley, and shelterbelts across the valley in in the form of copses or spinneys, backed up where possible by tree planting along streams and water channels, break up and deflect wind. The planting of trees for shelter-belts has long been practised in Canada and Russia. According to Jacks and Whyte (3) the U. S. S. R. planned to establish 665,000 acres of shelterbelts in the second five-year plan, as compared with the maximum of 1,282,000 acres in the United States, planned to be spread over ten years.

In the North-West Frontier Province all cultivated areas and nearly all the lower valley land is private property, and therefore afforestation can only be undertaken with the introduction of farm forestry. Once created, the farm forest units whether woods, orchards or hedgerows are more likely to remain permanent features of the landscape than so-called village forests, which are jointly owned or in which rights are shared. In the former the woodland becomes part of the farmed estate, whereas the *guzara* or civil *rakh*, is a detached unit in which each shareholder is concerned with obtaining as much as he possibly can, knowing that if he does not do so, his neighbour will. The practice of using forests on common land to clear the debts of the more influential, the absence of adequate grazing control measures and the discord among the parties concerned, has, during the past 50 years, resulted in the destruction of thousands and thousands of acres of forest.

Browsing and Grazing

A great deal of this deforestation would have been avoided, but for continuous heavy browsing and grazing, because most types of forests natural to the locality regenerate themselves if permitted to do so. Most of these deforested areas in the North-West Frontier Province occupy head-water catchments where the absence of conservation has resulted in extensive damage to valuable property in the valleys, in spite of the quite considerable efforts at downstream control by villagers to train rivers and protect their agricultural land. In the hills of Peshawar district west of the Indus a civil *Rakh* was divided; 13,000 acres being apportioned as forest reserve, and the balance handed over to villagers. This proved a most successful measure, and the forest department has been able to reforest the 13,000 acres of scrub type of forest in a region of less than 20 inches annual rainfall. The handing over of the Cherat cantonment forests, including a valuable water catchment area, to the forest department has also resulted in complete reforestation, although the whole area was heavily overfelled and overgrazed. On the other hand, progress in the Peiwar Kotal reserve (conifer and holly-oak type) has been poor, because protection from browsing could only be effected on a very small scale. Many of the forests and pasture lands in the North-West Frontier Province are right-ridden by landlords' herds and their tenants' herds and by nomadic graziers; the forest department must continue to refuse to take over land unless absolute control is guaranteed. In the case of private land handed over by owners to the forest department for afforestation and restoration, a guarantee of 10 years closure has been given. In the opinion of the writer this period needs

(3) JACKS, G. V., and WHYTE, R. O., 1939. The rape of earth.

extending to 15 years in dry zone regions of less than 25 inches annual rainfall. At any rate goats and camels should be excluded from the forest. Up-to-date more than 16,000 acres have been taken over on behalf of private owners, mainly in the northern districts west of the Indus, where the annual average rainfall is as low as 11 inches in the driest parts. The average for the areas taken over probably falls between 15 and 20 inches, rising to over 20 inches in the northern portion of Mardan district. The slopes of the areas taken over are generally steep except near the base where gradients are frequently low except along *nallahs*. The majority were in an advance state of deforestation; cultivation had been undertaken on some of the gentler slopes. Most of these units taken over for restoration require about 40 per cent canopied forest including *nallahs*, about 40 per cent can be most economically restored as wooded grass lands with contour belts of trees to prevent erosion. About 20 per cent will be suitable for cultivation of grass, orchards or other crops, when soil and water conditions are restored and properly conserved. From the experience gained during the past 2 years the writer is convinced that absolute closure to grazing combined with up-stream *nallah* control and contour control, including trenching, line sowing and planting and ridge terracing, will completely restore these areas. Experience shows that we must stick to xerophilous types of trees and shrubs, which include many useful species such as *sanatta* (*Dodonaea viscosa*), *phulai* (*Acacia modesta*), *Zizyphus spp.* and olive (*Olea cuspidata*). At high elevations *Quercus ilex*, *Elaeagnus glandulosa* and *Juniperus macropoda* are found, and *Acacia arabica*, *Prosopis spicigera* and *Tamarix articulata* at low elevations. The mesquite, *Prosopis spp.* is now well established in the dry zone.

Survey of Results

The following is a brief survey of results based on observations up to date in the North West Frontier Province :—

In the trans-Indus dry zone attempts at capturing water to irrigate *shisham* (*Dalbergia sissoo*) on the lower easier slopes have failed, and it appears essential first to secure up-stream afforestation in order to raise the water level sufficiently.

Dry zone species should be grown in dry zone regions. Check damming with the object of silting up *nallahs* and using the silt for sowing and planting has given uniformly excellent results. A large number of temporary dams, and a few premanent dams to check spates during the early stages of this important work, appears to be the best method. Trees and shrubs anchor the silt and convert temporary dams into premanent dams. In the North-West Frontier Province there are now thousands of miles of eroding *nallahs*, useless to man and beast and a menace to the countryside; most of the water and soil is carried away by these *nallahs*, and their afforestation is a matter of urgency. They must be controlled upstream, *i.e.* from the top.

Contour trenching has given good results up-to-date. A series of two or three overlapping trenches, 12 ft × 1 ft. × 1 ft. (maximum dimensions)*, is preferred to longer trenches, because it is very difficult to grade a long trench absolutely level on slopes. Sowing in the trench has given better results than sowing on the berm, and sowing after the trenches have received sufficient silt and water has given best results. The provincial silviculturist has recommended waiting a year before sowing.

On hot slopes the protection from insolation and the capture of water does seem to benefit plants. In some cases the mistake has been made of trenching a whole hill-side, which is expensive and unnecessary; one double series for every hundred yards of slope should be sufficient.

Line sowing has also given good results. Lines must follow the contour and, on rocky or undulating ground, short level lines are preferred to miniature Roman roads. Line sowings facilitate tending, and transplanting from the single line of seedlings is also easily undertaken. (Most species can be transplanted if the soil is removed with the roots). Width of lines varied from 4 inches on steep ground to 1 foot on easy ground and the distances between lines will vary according to whether the aim is a fully canopied forest or pasture with belts of trees. When working the soil for sowing, the inner half of the seed bed should be slightly sloped towards the hill-side as this traps run-off water and prevents the top soil being washed away. On badly eroded land it will

* On loose soil the sides of the trench should be sloped.

probably be advisable to allow the natural vegetation to recover before preparing and sowing lines, this will increase collection of moisture from dew, and the shade afforded to the seedlings from the grass and other herbs is most beneficial on hot aspects.

Contour ridge terracing is confined to easy slopes utilisable for cultivation; the intention is to grow hedges along these terraces. Rocky and precipitous ground is best left to nature to restock.

All the above contour control measures are designed to restore forest, soil and subterranean water simultaneously.

Summary of Suggestions for Afforestation

A. The right to enforce complete closure to grazing and grass cutting: When expedient encourage grass cutting.

NOTE—In the case of land under private ownership handed over to the forest department for restoration, complete closure must be guaranteed for the minimum period considered by the forest department to be essential for afforestation.

B. A joint policy for Provinces and States for the reduction of goats and their exclusion from the Forest.

C. Catchment Control Legislation to be enforced in cases where deforestation is resulting in damage to property within and below the catchment.

D. The highest priority to be given to the dry zone species experiments.

E. Experimental sowing of desert and semi-desert herbs for affording soil cover and fixing sand dunes.

(North Africa, Southern U.S.A., Mexico, U.S.S.R. each of the Caspian and Australia contain deserts which might supply useful exotics).

F. Upstream control by means of check dams and afforestation.

G. Contour control afforestation measures such as trenching, line sowing and ridge terracing.

H. The arising of wind-break plantations in cultivated estates, particularly along the border of irrigated and unirrigated land.

I. An increased production of fuel plantations on irrigated land to safeguard dry zone forests being overfelled.

J. The co-operative use of mechanization for soil control measures in Provinces and States which cannot afford the outlay or maintenance.

The North-West Frontier Province would welcome demonstrations.

WOOD FLOUR FOR PLASTICS AND EXPLOSIVES.

By Charles Lynch.

Cessation of overseas supplies of wood flour, a product of importance to secondary industry, particularly in the manufacture of plastics and explosives, has led to plans in Australia to add to the number of the flour producing mills. Types of local pine wood have been found suitable as raw materials.

The Division of Forest Products of the Australian Council for Scientific and Industrial Research is active in fostering interest in the possibilities of Australian wood flour production, and has conducted tests of local pine woods to illustrate their suitability.

Most of Australia's wood flour has been imported from Sweden, but the rapid post-war development of the Australian plastics industry has led to attention being given to local production.

The demand found the local industry somewhat unprepared, and temporary equipment has had to be installed in some cases, until orders for modern plants from Great Britain can be fulfilled.

Australian production costs are estimated to be considerably lower than prices of imported supplies and generally a bright future is predicted for the industry.

Main uses of the product are for linoleum, plastics and match heads and in the manufacture of explosives.

In addition, the mildly abrasive and absorbent qualities of wood flour have led to its use for the polishing of moulded plastics and metal and also plated articles. Other products which contain the flour are glues and cements, dolls heads, plastic wood, ceramics, electrical insulating materials and decorative wall-papers of the "oatmeal" type.

Sometimes the addition of the flour provides the basis of technical improvements in production, resulting in such benefits as a reduction in the density of heavy products or an increase in mechanical properties, especially, as in plastics, the impact resistance of units.

In the manufacture of dynamite or other blasting explosives wood flour is used in pre-

ference to other absorbent media, because in addition to its capacity to hold the nitro-glycerine it possesses the advantage of providing carbonacious material which is rapidly burnt in the excess oxygen set free during the explosion. It has thus the effect of increasing the force of the explosion.

Machinery used in the manufacture comprises wood pulverising and sifting units, with the necessary conveyers. Hammer mills break up the particles by impact, while the rotating stone, or steel grinding wheels of attrition mills tend to break up the sawdust into more fibrous particles.

In many plants in Australia a combination of grinders is used; hammer mills for preliminary break down and attrition mills to ensure a light fluffy product.

The flour is then screened to particle size by mechanical screening. This achieves a more uniform type of powder than when air separation is used. Air separators however, have been found useful in some sections of the industry where improvisation has been necessary on account of scarcity of supplies of other equipment.

Up-to-date devices to protect the production plants from damage by foreign matter such as metals, from fire hazards due to the heat generated, and from the damage of dust explosions, have been installed in the Australian industry. Precautions include electromagnetic devices to prevent damage by metals, while gravity traps are incorporated in the feed to eliminate other matter.

A small quantity of water is added to the sawdust processed through the stone mills. The high-grade product for technical purposes is usually made from a limited number of timber species, selected with regard to colour, density, and specific suitability. Acidic woods such as oak and dark-coloured woods, are not favoured because of their possible chemical action or discolouring of the paler products. The raw material must also be free from bark, grit and other foreign matter.

In Australia, wood flour is made in both impact (hammer) and attrition type of mills. Plants are located mainly in Sydney and Melbourne.

At the present time the various industries which are served by the wood flour mills are experiencing such rapid expansion that the mills have been able to supply their full demands.

Producers of the flour see a profitable field for expansion and development, more particularly as the Au.tralian pines, radiator and hoop, have been revealed as suitable for manufacturing purposes. If plants can be placed near supplies of sawdust from these species, the Australian industry will be expanded considerably and opportunities will be made for consequent development of many industries utilizing the wood flour in their products.

EXTRACTS

CHEMICAL UTILIZATION OF WOOD : ITS OPPORTUNITIES AND OBSTACLES[1]

BY ALFRED J. STAMM.

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Chemical utilization of wood has been discussed in several articles in previous issues of the JOURNAL OF FORESTRY, but in none of these has the subject been treated as comprehensively as in the following paper, which covers pulping, extraction, hydrolysis, destructive distillation, reactions with other chemicals, and chemical treatments to improve the properties of wood. The author points out that no universally successful method of utilizing inferior and waste wood has yet been discovered, but that developments to date make the future look encouraging. One unsolved problem is that of cheap transportation of large quantities of waste to processing plants. The chemist looks to the forester to solve this problem.

It is hardly necessary to point out to foresters, or even to Mr. Average Citizen, the huge amount of wood that is wasted each year in the United States. The Forest Products Laboratory receives letters regularly from those who are anxious to do something constructive in utilizing wood waste but who need help in doing so. This situation has been brought to the attention of Congress, which has earmarked a small increase in the Forest Products Laboratory appropriation for this fiscal year to be used in studying the chemical utilization of wood. It is hoped that this amount will be further increased in future years as the chemical approach to this important problem shows much promise of making important contribution to the eventual solution of the waste problem on an economic basis.

Although the Laboratory's approach to the problem is from the chemical standpoint, it will take more than the chemist to solve it adequately. Even if all the chemical facts regarding a potential utilization process were known, there would still be the necessity of determining its economic and mechanical feasibility. Economical harvesting and transporting of wood waste so that it can be delivered cheaply for chemical use seems to be the biggest obstacle confronting the chemical utilization of wood. This phase of the over-all problem is the one in which foresters and engineers can make their biggest contribution. Those who are anxious to contribute to the solution of the waste-utilization problem can well focus attention on harvesting and transportation of woods waste in small log, cordwood, chip, or sawdust form.

TYPES OF CHEMICAL UTILIZATION

The chemical utilization of wood may be divided into several types of processes: (1) pulping, (2) extraction, (3) hydrolysis (converting carbohydrates to sugars), (4) destructive distillation, (5) reactions with various chemicals such as hydrogen and chlorine, and (6) chemical treatments to improve the properties of wood and make possible the utilization of inferior species for structural use.

PULPING

Pulping is the oldest and best known of the processes for chemical utilization of wood. Experience has shown, however, that pulping cannot be done profitably on a small scale. Large-scale and costly equipment is necessary for efficient and economical operation.

Attempts have been made to operate pulp mills on inferior-quality wood and wastes. In a few instances these attempts have been successful. A notable example is the pulping of chestnut chips that have been extracted for tannin. In general, operators who have tried using low-grade wood have abandoned its use and turned to high-quality material in order to increase the returns from their investments. As quality material becomes less available, these operators can and will return to the use of the less desirable woods.

[1]Presented before the South-eastern Section, Society of American Foresters, Auburn, Alabama, October 26, 1945.
[2]Maintained at Madison, Wisconsin, in co-operation with the University of Wisconsin.

Development of a simple means of barking hardwoods at all seasons as well as small crooked softwood logs will help materially in getting the pulp mills to use more of the unpopular species and lower grade woods. Softwood mill waste is now being utilized by some pulp mills operating in conjunction with a sawmill. All logs going to the mill are prebaked. The slabs and, for some forms of paper, even the sawdust are being used for pulping.

Work at the Forest Products Laboratory on diversification of pulping species, notably the pulping of southern resinous softwoods and the semichemical pulping of hardwoods, has gone a long way toward making all available species suitable for pulping. The inclusion of some hardwoods in southern pine pulping operations has been shown to be practical and highly advantageous from a silvicultural and economic standpoint. Foresters can aid in getting various mill operators to follow such practice.

Efforts are being made to utilize more completely pulp-mill waste liquors. These liquors contain soluble lignin, hemicelluloses, and wood extractives which have considerable potential chemical value. In the sulfate pulping of southern yellow pine, turpentine and tall oil are now being recovered to a limited extent. Yields of tall oil as high as 200 pounds per ton of pulp are obtained. The tall oil is finding use in drying oils and soaps. Further purification and fractionation should increase its value and uses.

Sulfite waste liquor is being used to some extent as a dust settler for roads. Lignin is finding use as a dispersing agent for cement in the making of concrete; it is being incorporated in the negative-plate paste of electrical storage batteries; and it is used in making vanillin, the active constituent in vanilla extract.

Co-operative research between the Forest Products Laboratory and a Canadian mill has demonstrated the possibility of using soda-mill lignin in laminated plastics. Soda-mill lignin is the simplest to isolate and has the best plastic properties of the various forms of lignin waste. It can be incorporated with the pulp in a beater to form a laminating sheet which requires no auxiliary resin to produce a dense plastic material with good properties. The Forest Products Laboratory has also shown that soda-mill lignin can be used as a phenolic-resin diluent. The lignin is dissolved in a laminating resin solution and can be applied to paper or fabric. It can replace 50 percent of the phenolic resin ordinarily used without significantly affecting the properties of the resulting laminate.

The hemicellulose portion of pulping-waste liquor has received less attention than the lignin, although it is present in the liquor in at least equal amount. The hemicelluloses are converted almost entirely to sugars in the sulfite process. In the soda process they are much less degraded and can be isolated as starchlike products.

The sugars from the sulfite process are, to some extent, being fermented to ethyl alcohol and used for growing yeast, as will be described later. Ethyl alcohol is produced only from the hexose sugars and not from the pentose sugars. The pentose sugars can, however, be used for growing of yeast or fermenting to other products.

The chemistry and possible uses of hemicelluloses are being studied by the Forest Products Laboratory, where it has been shown that hemicelluloses can be isolated from wood in a practically undegraded form by a new potential pulping process. Practically all the carbohydrate constituents of wood (holocellulose) are isolated as a single solid fraction by subjecting wood chips to a semichemical pulping, followed by chlorination and mild alkali extraction. Various hemicellulose fractions can be extracted from the holocellulose by progressively stronger solvents, leaving a residual pulp that is considerably higher in alpha cellulose (undegraded cellulose of high molecular weight) than normal pulps, and which shows promise of finding use in cellulose derivatives. Such a pulping method would not only give extra high yields of high-quality pulp, but would also make possible the isolation of valuable hemicellulose by-products.

EXTRACTION

Extraction processes can be profitably applied to only a relatively few species, such as the turpentine and rosin extraction of southern pine stumps and tannin extraction of chestnut and hemlock. These processes utilize only a small portion of the wood. The problem of utilising the rest of the wood profitably still exists. This has in some instances been accomplished by pulping the extracted chips. For this use the wood should be barked prior to chipping and

extraction. Extraction of wood for chemicals on a scale too small to use the spent chips for pulping may eventually become profitable if other means of utilizing the residual wood substance are found. Expanding the wood-extraction industries thus depends to a large extent upon finding uses for the extracted chips.

HYDROLYSIS FOR PRODUCTION OF ALCOHOL

Next to pulping, wood hydrolysis has received major attention as a chemical utilization process at the Forest Products Laboratory during the last few years. Ethyl alcohol (grain alcohol) can be made from wood waste by hydrolyzing the carbohydrate portion of the wood to sugar, followed by fermentation of the sugar to alcohol. The general principles of this conversion have been known for years. At the time of World War I and shortly thereafter a process known as the American process, using southern yellow pine woods waste, was in operation in plants at Georgetown, South Carolina, and at Fullerton, Louisiana. The process, which consisted of a single rapid digestion of the wood with dilute acid followed by extraction of the sugar and batch fermentation of the sugar liquors, produced about 26 gallons of 95-percent alcohol per ton of dry wood. Each plant produced about 2,500 gallons per day. Operation of these plants was finally discontinued because of the lack of adequate woods waste near the plants and the substantial lowering of the price of blackstrap molasses (to 5 cents a gallon) from which alcohol could be produced more cheaply.

About 1928 a multiple-cycle, dilute-acid-hydrolysis process, known as the Scholler process, was developed in Germany. Yields of about 45 gallons per ton were obtained from hardwoods and 53 gallons per ton from softwoods. Cooking times, however, ranged from 16 to 20 hours. During World War II pilot-plant studies were intensively undertaken by the Forest Products Laboratory, first to duplicate and then to improve on the German process. This work has resulted in what is called the Madison wood-sugar process. Cooking liquor is continuously pumped through a bed of wood waste for 2½ to 3 hours under properly controlled conditions, followed by a continuous fermentation. Yields of 55 to 65 gallons per ton of bark-free softwood waste have been obtained. The improved yield, together with the reduction in cooking time to as low as one-sixth to one-eighth of that for the Scholler process, gives the process a better commercial outlook. A government-sponsored plant designed to produce 5 to 6 million gallons of alcohol a year from about 380 tons of sawmill wood waste per day by this method is under construction at Springfield, Oregon.

According to the Forest Products Laboratory experiments, wood with bark content as high as 50 percent can be handled, but with a significant drop in yield. Hardwoods can be used instead of softwoods. Although the alcohol yield drops to about 45 gallons per ton, larger amounts of valuable by-product wood alcohol and furfural can be recovered to offset the loss in ethyl-alcohol yield. The Laboratory has also shown that yeast can be grown on the still bottoms, after recovery of the alcohol, to produce about 200 pounds of fodder-yeast by-product per ton of dry wood.

From each ton of wood processed there is about 650 pounds of residual lignin. As yet a profitable use for this residue has not been found. Present plans are to use it as a fuel in the plant boilers. This lignin is in a highly insoluble form and is not suitable according to present information for use in plastics in the same way as lignin residue from soda pulp. Work is under way at the Laboratory in the search for profitable uses for this residue.

This new alcohol process has created a great deal of public interest. In fact, almost everyone with a little sawdust pile wants to make alcohol. It is thus important to look at some of the economic aspects of the problem.

Consider wood waste in a hogged form delivered at the chemical plant to be worth $2.00 per ton on a dry-weight, bark-free basis. Moisture and some bark are acceptable but a processor will not pay for them. The wood cost per gallon of 95-percent alcohol would then be about 4 cents and the chemical cost would be about 6 cents. On the basis of a plant processing 60 tons of dry, bark-free waste per day (approximately 200 tons with bark and moisture), labor would cost about 8 cents per gallon of alcohol and plant investment and upkeep 16 cents a gallon. The production cost of alcohol would thus be 34 cents per gallon, a figure within reason. In a larger plant labor charges may be as low as 5 cents per gallon. On the basis of a 10-ton-a-day plant the total labor required would be almost the same as for a 60-ton plant, which, on the smaller daily output, would amount to perhaps 45 cents per gallon. A

10-ton-a-day plant might cost two-thirds as much to build as a 60-ton-a-day plant, bringing the plant investment and upkeep cost to 64 cents per gallon of alcohol. The production cost of alcohol from the 10-ton plant would thus be $1.19 per gallon. It is evident from these figures that the manufacture of alcohol from wood is necessarily a large-scale operation.

There is the possibility of hauling wood waste from several mills to a central chemical plant. By present handling methods it appears that wood waste cannot be profitably hauled much more than about 10 miles. This is the radius of haul tentatively chosen as economical for the Springfield wood-sugar plant.

Comparative cost of alcohol produced by other methods has a direct bearing on the commercial application of the process. Alcohol is being produced in the State of Washington and in Canada from sulfite-pulp waste liquor. Plant costs are about the same as estimated for the Madison wood-sugar process. No hydrolysis step is involved but, because of the more dilute liquor, larger volumes have to be handled. Production costs on a large-scale plant basis would probably be about 25 cents per gallon, which is somewhat less than the estimated cost of production by the Madison wood-sugar process. Alcohol was produced from blackstrap molasses at about 20 cents per gallon when the cost of molasses was 5 cents per gallon at the plant. At the present molasses price of 18 to 20 cents per gallon, it would cost 50 to 56 cents a gallon to produce alcohol from this source.

Ethyl alcohol made from grain, at present grain prices, ranges in production cost from 85 cents to $1.50 per gallon, depending on the size and efficiency of the plant. Ethyl alcohol can be produced from petroleum at a somewhat lower cost than by the Madison wood-sugar process. It is hard to say, however, whether the petroleum companies will turn to making alcohol as long as they can make more profitable products. It thus appears that the future of making ethyl alcohol from wood waste depends upon the cost of balckstrap molasses not falling below 10 cents per gallon and the petroleum industry not going into the manufacture of alcohol. Finding a profitable use for the residual lignin will also materially help the production of ethyl alcohol from wood. If all the sulfite liquor from pulp mills producing more than 100 tons of pulp a day were fermented, alcohol production from this source would be about 30 million gallons of alcohol per year, which is about 3 percent of present annual production. Some mills are too small to produce alcohol economically.

OTHER FERMENTATION PRODUCTS

When wood sugars are fermented with the use of cultures and nutrients other than those used in producing ethyl alcohol, such products as acetone, butanol, 2, 3-butylene glycol, and lactic acid can be produced. These find use as solvents and as raw materials for making synthetic rubber and plastics. As yet, available data on these processes are insufficient to indicate how they should be carried out commercially and what the cost of production will be.

Fodder yeast can also be grown on the total sugars as well as on the still bottoms. The extent to which this vitamin-containing food can be used profitably for feeding is still unknown. Cattle can assimilate urea, the nutrient ordinarily used in growing fodder yeast, and convert it into protein. It still remains to be proven whether fodder yeast is a better food for cattle than urea and to what extent it may replace other natural protein-containing foods. The quantity of fodder yeast made in this country up to the present time has been insufficient to make adequate feeding tests. This situation, however, should change soon.

HYDROLYSIS FOR PRODUCTION OF PLASTICS AND BOARD MATERIALS

Pioneer experiments by the Forest Products Laboratory showed that lignin, in a sense nature's cementing material between the cellulose fibers, can be freed from the cellulose by a mild acid hydrolysis and be subsequently used as a semiplastic to bond the structure together again. Besides breaking the cellulose-lignin bond, the mild hydrolysis converts the hemicelluloses to sugars, while the stable cellulose remains with the lignin to serve as a plastic reinforcing material. The removed sugars can be either fermented or used for the growing of yeast. The residue is dried and then ground to a powder.

Although this hydrolyzed residue has some plastic properties, it does not make a good plastic when used alone because of the extremely high temperature necessary to cause the lignin to flow even moderately and the relatively low water resistance of the product. For this reason

it is preferably used in conjunction with other plastics such as phenol-formaldehyde, which improves both the flow and the water resistance. Under these conditions a plastic quite similar in appearance, water resistance, and electrical properties to common black phenol-formaldehyde plastics can be made using 75 percent of hydrolyzed wood and 25 percent of phenolic resin. This can be contrasted with the 50 percent of wood flour and 50 percent of phenolic resin used in making the ordinary phenol-formaldehyde molded products. The strength properties, notably toughness, are slightly lower than for the normal phenol-formaldehyde molded products, mold flow is also inferior, but acid-resistance properties are better.

A commercially developed modification of the Forest Products Laboratory acid-hydrolysis process, in which the wood is hydrolyzed with an alkaline medium that becomes slightly acid at the end of the cook, gives a similar molding powder with superior strength properties to those of the acid-hydrolyzed product. This material, when used with only 25 percent of phenolic resin, still lacks the rapid and more extensive flow of the ordinary phenol-formaldehyde molded products. Although the addition of more resin improves the flow, it reduces the price advantage.

It is this lack of flow that has held back the commercial use of hydrolyzed-wood plastics. In large objects with limited need for flow, hydrolyzed-wood plastics may, however, be used to advantage because of the lower cost. On the basis of the phenolic resin costing 20 cents a pound, wood flour costing 2 cents per pound, and hyrolyzed wood costing 4 cents a pound, the raw material for the hydrolyzed-wood plastic would cost 8 cents per pound, in contrast to 11 cents per pound for the present material.

Research is under way at the Forest Products Laboratory to put the lignin into a more plastic form so as to improve its flow characteristics and also to avoid the embrittling effect on the cellulose caused by the hydrolytic methods that have been used to date.

The hydrolyzed-wood plastic requires pressures of 3,000 to 4,000 pounds per square inch at elevated temperatures for molding similar to the present molding powders. This necessitates expensive presses and molds. There is a crying need for molding compositions that can be cold formed in a simple handpress, perhaps followed by a simple baking. This problem, too, is being attacked at the Forest Products Laboratory. The chief difficulty to date has been that the simpler, cheaper compositions which are readily hand molded all exhibit considerable shrinkage on baking.

Unfortunately, none of the molding compositions show promise of utilizing very large quantities of wood waste. For example, if all of the present phenol-formaldehyde molded products were to be replaced by the hydrolyzed-wood plastic, three moderate-sized lumber mills could furnish all the raw material needed in the country. As board materials show promise of larger volume consumption, considerable attention has been devoted by the Forest Products Laboratory to making such materials.

The hydrolyzed-wood molding powders are not suitable for making board materials with adequate strength properties, notably toughness. The strength properties can be greatly improved by having the cellulose reinforcing material present in longer-fibered form. This can be accomplished by using hardwood chips in place of sawdust and abrading the washed hydrolyzed chips while still wet to a pulp rather than grinding to a powder after drying. This pulp can be made into paper on a paper machine. After incorporating 10 to 15 percent of phenolic resin, these sheets can be pressed at elevated temperatures and a pressure of about 2,000 pounds per square inch into a high-density board with quite good strength properties and water resistance. The board cannot be nailed but can be drilled. This, together with its high density and molding cost, do not make it attractive for general housing applications. It should, however, be suitable for electrical paneling and such purposes as shower-bath walls.

More recently pulp boards have been made by the Forest Products Laboratory from the hydrolyzed chip fiber by forming thick pulp mats that are pressed wet under a pressure of 100 pounds per square inch or less without the addition of any phenolic resin. These boards have quite good properties comparable to those of untempered commercial hardboards. They have a specific gravity of about 1.0, can be nailed, and can be made from softwoods as well as hardwoods; but the strength properties and water resistance of the softwood product are somewhat inferior.

Although these and other similar hardboards show promise for use as a sheathing material

for houses and in other ways that wood is used, they are far from being synthetic lumber. Their use in housing will, undoubtedly, expand. Some new producers will undoubtedly succeed. If all who have contemplated production of these board materials actualy go into production, however, a state of overproduction will be inevitable.

Destructive distillation

Prior to the development and the industrialization of the present process for making synthetic wood-alcohol, wood distillation was a profitable industry. Only a few plants have survived this development. During the war period, however, considerable interest in distillation has been revived, largely because of the increased demand for charcoal. No new extensive plants have been built, but some charcoal manufacture without recovery of volatiles has been renewed.

There is still, the possibility of reviving the wood-distillation industry by introducing new principles of distillation that will result in other than the conventional products. Such distillation principles can be applied to lignin residues, from which it has been shown that valuable phenolic compounds can be obtained. The Forest Products Laboratory is again launching on a destructive-distillation research program after an inactive period of about 20 years, as it is felt that the introduction of new techniques may revive an idustry that under the old methods does not have a promising post-war outlook.

Hydrogenation of wood

Pioneer research at the Forest Products Laboratory has shown that lignin dissolved in organic slovents or suspended in water can be made to react with hydrogen gas at elevated temperatures and pressures in the presence of various metallic catalysts. Among the products of the reaction are several new cyclic alcohols that had never been previously described in the literature. These show promise as plastic solvents, antiknock agents for motor fuel, and toxic agents. By varying the hydrogenation conditions, phenolic compounds which may find use in plastics and complex neutral oils, together with a plastic-like residue, are obtained.

Wood waste or chips can also be hydrogenated in aqueous suspension to produce soluble lignin decomposition compounds and a cellulose pulp residue. This is a possible new pulping process that will be studied further by the Forest Products Laboratory. Under more severe hydrogenation conditions the cellulose can be converted to glycerine and sugars. In this case the entire wood is converted to liquid products.

All these findings are too new to predict their future application. Most of the data have been obtained in small bombs and in continuous-hydrogenation equipment designed for other hydrogenation reactions. Continuous-hydrogenation equipment is being built at the Forest Products Laboratory for continuing this work.

Modified Woods

The modification of wood by chemical treatments and by compression has excited a great deal of interest during the war period as a result of the publicity which the materials have received. These modified woods should not be thought of as improved forms of general-utility lumber, as has often been inferred, but as specialty materials for uses where their special properties are needed.

Impreg

Wood treated with phenolic-resin-forming chemicals according to the Forest Products Laboratory method in which the chemicals enter and bond to the cell-wall structure, followed by drying and curing of the resin within the structure, is known as impreg. When resin is thus made an intimate part of the wood the tendency of the wood to swell and shrink is permanently reduced. Phenolic-resin-forming systems have proven to be the most effective in dimensionally stabilizing wood. Reductions in the equilibrium swelling and shrinking to 30 percent of normal are possible with phenolic resins. Urea resins, which have been highly publicized of late for this purpose, reduce the equilibrium swelling by only half as much.

Stabilization of wood by a resin treatment differs from preservative and fire-retardant treatments in that it must be much more complete. The resin must be uniformly distributed throughout the entire cell-wall structure to be fully effective. For this reason the treating of lumber and the treating of freshly felled logs has not met with the success that some investigators have claimed. The Forest Products Laboratory has found that veneer of practically any species and many species of solid wood in lengths up to a foot or two can be adequately treated. Practically none of the

woods can be treated properly in lumber lengths. Even if lumber could be adequately treated, the increase in cost would make the material prohibitively expensive for the majority of proposed uses. It is nevertheless felt that the resin treatment of veneer for facing of plywood and for various specialities will find considerable use.

The face checking of plywood can be practically eliminated merely by facing normal plywood with phenolic-resin-treated faces. The treatment also imparts to the panels considerable resistance against decay, termite, and marineborer attack. A panel consisting of two resin-treated face plies with a single untreated core ply was inserted in the ground for 1 year in a field in Mississippi where termite action is severe. The termites tried the faces but found them not to their liking. Like good soldiers who have failed in a frontal attack, they tried a flank attack, and, finding the core, just what they wanted, proceeded to clean it out. Similar material that has had the edges protected with a preservative treatment and material with all the plies treated are, in some instances, sound after 5 years.

The resin treatment further cuts down the passage of water vapor through the panels to a marked extent, greatly increases the electrical resistance and the resistance to most chemicals with the exception of strong alkalies. Contrary to many of the publicity claims, resin treatment has a negligible effect in improving fire resistance. Fire-resistant salts, however, may be incorporated into the wood together with the treating resin and fixed in the structure by the treating resin to give quite good fire-retardant properties.

Only a few of the strength properties of wood are significantly increased by a resin treatment and the toughness is significantly decreased, which is contrary to much of the publicity on resin-treated wood. The only properties that are significantly increased are hardness, compressive strength, and abrasion resistance, and these are increased to a greater extent than the weight only at high resin contents.

Impreg was manufactured during the war only for military uses. One of these was for housings for electrical control equipment, in which the improved electrical properties are taken advantage of; the other was for the facing material for laminated aircraft-carrier decking, in which the improved abrasion resistance is utilized. Impreg shows the greatest promise for post-war use as resin-treated faces for ordinary plywood. Such panels might be used as house, trailer, and box-car siding, flooring, and paneling. It still has to be proven, however, that the improved properties warrant the increased cost.

Compreg

Compreg is the name given to the Forest Products Laboratory's stable form of resin-treated compressed wood. Its dimensional stability, resistance to organisms, chemicals, and flow of electricity are practically the same as for impreg. Most of the strength properties are increased about in proportion to the compression. It is tougher than impreg but not quite so tough as the original wood.

Due to the plasticizing action of the resin-forming chemicals on wood at temperatures used in hot pressing, the treated wood can be appreciably compressed under a pressure which scarcely compresses an untreated control. Because of this plasticizing action of the resin-forming chemicals on wood, it is possible to make a combination of resin-treated compressed faces on an untreated uncompressed core in a single assembly and compression operation. It is felt that in this form compreg will find most of its post-war uses.

When compreg is compressed to a specific gravity of about 0.9 to 1.4, it assumes a glossy finish which persists throughout the structure. A cut surface can be sanded and buffed to a high degree of finish without the use of applied coatings. This is a feature of compreg which would make it desirable for use in furniture and flooring. Panels with a yellow-poplar compreg face, a yellow-poplar impreg back, and a Douglas-fir plywood core have been made for a flooring service test that is now under way in one of the Forest Products Laboratory offices.

Compreg, largely in the form of thick, highly compressed panels, has been manufactured during the war by seven companies for war use, chiefly in the manufacture of propellers. Compreg has also been used to some extent for various connector and bearing plates, aerial antenna masts, and tooling jigs. Solid compreg shows promise for post-war use in pulley and gear wheels, bearings, and tooling jigs; shuttles, bobbins, and picker sticks for looms; high-strength electrical insulators; knife handles; and various decorative novelties. Compreg has

better strength properties than fabric-reinforced plastics, and it should be appreciably cheaper since veneer is cheaper than fabric and about half as much resin is used in making Compreg as in the fabric reinforce plastics. Compreg may thus replace these plastics in a number of use.

Staypak

Resin-treated wood in both the uncompressed and compressed forms is, unfortunately, more brittle than the original wood. To meet the demand for a tougher compressed product than compreg, a compressed wood containing no resin was developed by the Forest Products Laboratory. It will not lose its compression under swelling conditions as will ordinary compressed wood. This material, named staypak, is made by modifying the compressing conditions so as to cause the lignin cementing material between the cellulose fibers to flow sufficiently to eliminate the internal stresses.

Staypak is not so water resistant as compreg, but it is twice as tough and has higher tensile and flexural properties. The natural finish of staypak is almost as good as that of compreg. Under weathering conditions, however, it is definitely inferior to compreg. For outdoor use staypak should have a good synthetic-resin varnish or paint finish. Staypak can be used in the same way as compreg where extremely high water resistance is not needed. It shows promise for use in propellers, tool handles, forming dies, and connector plates where high impact strength is needed.

Stabwood

The cheapest and simplest method of imparting dimensional stability to wood thus far found is to heat the wood under conditions that just avoid charring. This can be done with a minimum loss in strength properties by the Forest Products Laboratory method of heating under molten metal for a few minutes. The wood becomes dark brown in color, loses about half of its original toughness, together with moderate losses in other strength properties. Equilibrium swelling and shrinking can be reduced to 60 percent of normal and an appreciable decay resistance is imparted to the wood by this treatment. Stabwood may find some use in places where dimensional stability and moderate decay resistance are more important than strength.

Conclusions

Although a great deal has been accomplished in developing means of chemically utilizing wood and in making modified woods, no universally successful process of utilizing the vast amount of inferior or waste wood has been developed. Individual operators, however, may be successful in using any of the processes discussed. Their success will largely depend upon making careful surveys of the source of wood supply, markets, and economical size of the prospective plant before venturing into any extensive operations.

Although the modified-wood field is primarily based on using high-quality wood chiefly in the form of veneer, there is the possibility of some manufacture based on the use of short dimension stock that is classed as waste because of size rather than quality. Compreg knife and other handles, knobs, and various decorative novelties can all be made to advantage from short lengths of solid wood rather than from veneer. The increased value of the product would make possible a more scrupulous selection of wood than would be possible for similar products made from untreated wood.

Further research on chemical utilization and modification of wood will undoubtedly expand the present possibilities of waste utilization, but the chemist needs the help of the forester in working out the problem of delivering the waste cheaply in large quantities to the processing plants.

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SOILS OF INDIA AND SOIL SURVEY

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The objects of the soil survey are (i) to classify the soils according to their characteristics, (ii) to show their distribution on maps, and (iii) to describe their characteristics particularly in reference to the growth of various crops and plants. The ultimate purpose is to provide accurate soil maps, which would show the location and extent of the various kinds of soil.

So far in India, soil survey has not been carried out on any systematic or planned basis. The scattered work that has so far been carried out may be divided into four broad categories :

1. *Soil classification from geological point of view* : In this system the soils are grouped according to the geological character of the rocks which underlie the soil.

2. *Land assessment classification :* This system has been used mainly by Settlement Officers and is based on the suitability of soils for certain crops under local conditions. The main factors which govern such a system of classification are the texture, colour, availability of water and yield of crops.

3. *Soil classification from physico-chemical properties of surface samples* : The classification is based mainly on the contents of nitro gen, phosphorus and potassium useful to plants, *i.e.* on the nutrient status, lime content and the mechanical composition of surface soils and subsoils. Such classifications are in the nature of soil reconnaissance and have been generally carried out from an agronomic point of view.

4. *The genetic classification :* In this system soils are divided into groups depending on their origin and development. The soilprofile is taken as the basis of study. Such studies have been carried out mainly in connection with irrigation or afforestation projects and in one or two instances for agronomic purposes.

All these investigations which have been so far carried out in India are rather scanty, considering the vast area of the country and, besides, most of these surveys have not been carried out by standardized methods.

Soil map of India

No accurate soil map of India is available so far. Such a map can be drawn only by the co-ordinated efforts of a large number of soil workers distributed all over the country working for a long time. It is recognized that such a type of survey will entail a heavy expenditure and will require a very long time, even if the co-ordinate activities of soil scientists all over India were marshalled. It is, however, a very fundamental work which should be taken in hand as early as possible. In the first instance, it involves provision for the training of men in methods of soil survey and thus creating a nucleus of soil surveyors which will develop the principles on which the ultimate soil survey will be carried out.

Classification of Indian soils

The soils of India may be broadly divided into the following classes :

1. Red soils including red loams, yellow earths, etc.
2. Laterite and lateritic soils.
3. Black soils of varying types, including the typical black cotton soils or regurs.
4. The so-called alluvial soils including deltaic alluvium, coastal alluvium and inland alluvium. The group is an ill-defined one the actual classification of which will depend on an elaborate study.
5. Mountain and hill soils.
6. Arid or desert soils.
7. Saline and alkaline soils.
8. Peaty and other organic soils.

Of the above classes of soils, the most extensive are (1) the red soils, (2) the laterite soils, (3) the black soils, and (4) the so-called alluvial soils. A brief account of the occurrences and properties of these four extensive classes is given below.

Red soils

The main features of the red soils, besides their being of a lighter texture and porous and

friable structure, are (i) the absence of lime *kankar* and free carbonates, and (ii) the usual presence of soluble salts in a small quantity usually not exceeding 0.05 per cent. These soils cover almost the whole of the Peninsular India outside the area of the Deccan trap and of the narrow strip of coastal alluvium. In fact the red soils comprise practically the whole of Madras, Mysore, south-east Bombay, east of Hyderabad State and a tract running along the eastern part of the Central Provinces to Chota Nagpur and Orissa. In the north the red soil area extends into and includes the greater part of the Santal Parganas in Bihar, the Birbhum district of Bengal, the Mirzapur, Jhansi and Hamirpur districts of the United Provinces, the Baghelkhand Agency of Central India, the Aravallis and the eastern half of Rajputana. Throughout this range, the red soils differ greatly in depth and fertility which under irrigation produce a large variety of crops. These soils are generally deficient in nitrogen, phosphoric acid, humus and lime. The clay fraction of the red soil is rich in kaolinitic type of minerals.

Laterite and lateritic soils

Laterite is a formation peculiar to India and some other tropical countries, with intermittent'y moist climate. It is characterized by compact to vesicular rock composed essentially of a mixture of the hydrated oxides of aluminium and iron with small amounts of oxides of manganese and titanium, etc. It is derived from the atmospheric weathering of several types of rocks under monsoon conditions of alternating dry and wet periods. It is specially well-developed on the summits of hills of the Deccan, the Central India, the Central Provinces, and of the Rajmahal and the Eastern Ghats, and certain parts of Orissa, Bombay, Malabar and Assam. The soils are deficient in potash, phosphoric acid and lime. On the higher levels these soils are exceedingly thin and gravelly, but on the lower levels and in the valleys they consist of heavy loams and clays and produce good crops particularly rice.

Black soils

The main features of the black soils are that (i) their depth varies from one to two or, as sometimes happens, to several feet, (ii) they are loamy to clayey in texture, (iii) they crack heavily in summer, the cracks reaching up to more than three or four feet in depth especially in the case of heavy clays, and (iv) lime *kankar* zone and free carbonates (mostly calcium carbonate) mixed with the soil are present at some depths. These soils are generally rich in montmorillonitic and beidellitic group of minerals. These may be grouped as tropical black earth or tropical tschernosems. These soils are generally suitable for the cultivation of cotton and extend over the greater part of the Bombay Presidency and also to Kathiawar, Berar, the western parts of the Central Provinces, Central India and Hyderabad and some parts of the Madras Presidency including the districts of Ramnad and Tinnevelly. The soils are generally deficient in nitrogen, phosphoric acid and organic matter, but potash and lime are usually sufficient. They are generally felt to be unsuitable for irrigation but investigations carried out by the Madras Government in connection with the Tungabhadra Project and those by the Hyderabad Government in connection with the Nizamsagar Project show that these soils may be irrigated without any deterioration if irrigation be carried out on sound lines.

Alluvial soils

The alluvial soils are distributed mainly in the northern, north-western and north-eastern parts of India including the provinces of Sind, Punjab, the United Provinces, Bihar, Bengal and parts of Assam and Orissa and also in the coastal regions of southern India including the areas of the mouths of the rivers, at which places they are known as the deltaic alluvium. From agricultural point of view these soils are the most important and most fertile amongst all the Indian soils. The whole of the Indo-Gangetic plain is comprised in this area of 300,000 sq. miles. The soils are deficient in phosphoric acid, nitrogen and humus but not generally in potash and lime. They produce a wide variety of crops, including rice, wheat and sugarcane. In Bengal and Assam the alluvial soil has been subdivided into two classes, *viz.* old and new alluvium which are however mainly geological groupings. The old alluvium which is red soil, is deficient in nitrogen, besides being deficient in phosphoric acid, lime and humus.

Methods of soil survey

The advancement of pedological knowledge has revealed the complex nature of the soil,

The Russian workers were the first to point out that for the study of the soil, morphology of the profile should be made the basis. It should also be recognized that soils may vary in their ecological and agricultural characteristics in spite of their similarity in external features. In such cases, besides the examination of the morphological features, a simultaneous determination of the chemical constituents present in the soils at different horizons together witht he determination of corresponding physical properties is necessary.

Soil survey has been highly advanced in Russia, America, England, Australia and other countries. The fundamental point which has been recognized everywhere is that for proper survey the observations are to be carried out mainly in the field to be supplemented by measurements in the laboratory where necessary.

It should be realized that there are many possible systems of soil classification each of which has a value for a particular limited purpose. Thus the earlier classification of soils based on the texture would be quite adequate for practical purposes for a limited area. There was a serious defect in this earlier system in that attention was restricted to the surface soil only. In the modern American system of classification which is a modification of the Russian system, soils have been divided into *World Orders into 'Pedocals' and 'Pedalfers'* according as to whether there is calcium carbonate accumulation in the profile or not. These World Orders are divided into Groups, Subgroups according to temperature, latitude *and rainfall. The Groups, Sub-groups* are again arranged into different categories based on profile characteristics. Soils with similar profile derived from similar material under similar conditions of development are conveniently grouped together as series which in America are named after the localities where they were first studied. A series is further subdivided according to textural variations and the textural distinctions are known as Types. In England the series system has been adopted with some adjustment. In the soil survey of Wales it has, however, been found convenient to make a preliminary classification into 'Suites,' intermediate between World Group and Series. The soils of a Suite are further divided into series according to the mode of development as reflected in the profile.

For a vast country like India a preliminary rapid reconnaissance survey will be useful followed by detailed planning for surveys in the different provinces and states. As far as possible, attempt should be made to classify Indian soils into World Groups, Series and Types.

Soil survey from the point of view of land *utilization survey*

The application of the results of soil survey to the problems of practical agriculture is frequently made through the intermediate step of some sort of land classification. A soil map, if properly prepared, becomes the basis on which the plan of land use is built up. For any sound project of land utilization, soil survey should be followed by investigation *along certain lines involving other agricultural* agencies, such as (i) the study of climate, (ii) the investigation of agricultural problems of the area, (iii) studies in agricultural economics, and (iv) the determination of potential land use. In America four major classes and one miscellaneous class are employed in mapping types of land use as follows: (i) cultivated land, (ii) pasture and grassland, (iii) woodland, (iv) idle land, and (v) urban areas, home sites, etc. Two major types of land conservation surveys are employed, *viz.* detailed and reconnaissance, and the physical facts determined by the land conservation survey can be evaluated in terms of *land use capability*, which is determined by the knowledge of the soil types.

It must be recognized that the productivity of a soil is the result of management practices. Some soils need only to be ploughed and cultivated to produce good yields. Others may respond little to such simple operations, yet with more intensive practices like fertilization liming, terracing, drainage or irrigation, or some combination of these, high yields of good quality may be obtained. Proper soil management with the units of soil classification and soil maps should form the basis of any planning of land utilization.

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EROSION IN THE JUMNA AND CHAMBAL REVINES *

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In 1945 Dr. Shuhart of the U.S.A. Soil Conservation Service toured India at the request of the Government of India. In the course of his tour, he visited ravine area of the Jumna and Chambal rivers in the United Provinces. To appreciate Dr. Shuhart's report, I give below a few brief notes on the terrain, the problem, and past management.

The terrain

The Jumna river is one of the principal tributaries of the Ganges. It is 860 miles long, of which over 500 miles lie in the Gangetic plain. Between Delhi and Allahabad it has five tributaries of which the Chambal, rising in the Central India hills, is the most important.

The ravines of the Jumna and Chambal rivers cover an area of several hundred square miles, particularly in the Etawah, Agra, Muttra, and Jalaun districts. In the Etawah district alone it is estimated that they cover an area of 120,000 acres.

The accumulated effect of flooding and scouring has resulted in the bed of the Jumna at Etawah being lowered 60 feet in the last 500 years. The absence of protective vegetation and the flow of water from the high plateau to the rivers has caused this complicated network of ravines. They often start suddenly at the edge of cultivation with a drop of 80 feet, but active erosion continues by the gullies eating back into the cultivated uplands. The general picture is therefore of an immense barren tract cut up by deep gullies with the broken ground between resisting erosion on account of the intercalation of layers of *kankar*.

The Problem

The problem facing Government is:

(*a*) The best economic land use of this vast ravine tract.

(*b*) The prevention of further erosion into the fertile lands of the Gangetic plain.

Past management

Except as noted below, this immense area is private property but the land at present is almost valueless to the owners as it yields only grazing of the very poorest description. The ravine tract is so completely drained that it is almost destitute of vegetation except for a semi-desert flora and even this is disappearing through over-browsing.

For all practical purposes the owners have done nothing to improve the economic value of the tract and have done absolutely nothing to prevent further erosion of the cultivated uplands. On the contrary their only source of revenue (fees from cattle and goats) has been a major cause of deterioration and a contributing factor to further erosion.

From 1914 onwards the forest department of the United Provinces leased from the owners a number of small isolated areas amounting in all to about 28,000 acres in the ravine tracts of Etawah, Agra, Hamirpur, and Jalaun districts as well as in the eroded areas of Cawnpore and Lucknow. Of these the largest is the Fisher Forest of Etawah consisting of about 2,800 acres. The object of leasing these areas was to demonstrate to the *zamindars* what could be done to stop erosion and to improve the economic value of their land by raising fuel plantations and improving the pasture. In

*Paper presented at the Seventh All-India Silvicultural Conference, Dehra Dun (1946), on item 4—Contour bunding and trenching as counter-erosion measures.

spite of the most difficult soil conditions, a fairly satisfactory fuel plantation has been raised in the Fisher Forest whilst careful scientific experiments over a long period of years have proved that simple grazing control increases the production of grass by ten times.

As demonstrations, however, the leased areas have proved useless as the *zamindars* have not been prepared to spend money on similar measures, whilst the local villagers have bitterly opposed restrictions on the grazing of their cattle and goats. Although the areas leased by the forest department are only tiny oases in an immense tract in which grazing is unrestricted the department had to give way to local pressure and permitted an incidence of grazing which they knew to be too high.

Future management

In my opinion the general policy was wrong. The *zamindars* cannot afford to spend the money necessary to tackle the problem even if they have the public spirit to do so. Whatever one's general views on private ownership, this particular land problem is a national problem which can only be tackled with the resources of a government strong enough to overcome local opposition in the interests of the country as a whole. Government should gradually acquire the entire ravine tract from the owners and take steps to control the incidence of grazing, probably through *panchayats* of the villagers themselves.

This is the policy which the forest department has in view. It has neither been rejected nor accepted by government, but government has at least sanctioned the purchase in 1945 of the areas formerly only leased from the *zamindars*.

There has been and there is bound to be bitter opposition both from the *zamindars* and the local villagers. To quote from the most recent representation (from the Secretary, Circle Congress Committee, Etawah):—

> "The underlying motive of the government officials appears apparently to be the destruction of the Indian sheep and goats so as to develop the import into India of Australian wool and such other products. We shall oppose such sinister step tooth and nail."

This particular ravine problem is only one of a hundred facing government in the better utilisation and management of waste lands to deal with which a land management circle has been created in the forest department, of the United Provinces from November 1945.

At the moment, famine conditions are forcing all governments to concentrate on increased production of agricultural crops under the "grow-more-food" campaign even in areas quite unsuitable for premanent cultivation. There may, therefore, be criticism of Dr. Shuhart's suggestion to stop cultivation round the heads of the gullies, but the long view must be taken some time or other to prevent the annual destruction of cultivated fields that is now going on through erosion. In this connection, however, immediate action should at least be taken on his suggestion to adopt contour farming and field bunding to preserve moisture in the cultivated uplands and to prevent the rapid spilling of water into the gullies which is one of the causes of erosion spread.

Apart altogether from the ravine problem, there is a danger of the grow-more-food campaign upsetting the general economy of the country to the detriment of other important factors such as pasture and fuel production. Mr. Chaturvedi has shown in his book that the economy of the Gangetic plain has already been upset by the absence or inadequacy of forest and pasture land. During the war the absence of forest in this area gave rise to acute problems of distribution and I was often reminded that there was no use providing the soldiers and urban population with food unless we also provided them with fuel to cook it. Dr. Shuhart has emphasised that the proper land use of the ravine tract is fuel and grass production.

The above note indicates the general position when Dr. Donald Vincent Shuhart visited India last year on the invitation of the Central Government. We were glad of the opportunity to take his advice on the technical aspects of the erosion problem in the Jumna and Chambal ravines.

When reading his report, it should be remembered that Dr. Shuhart had little knowledge and experience of Indian conditions but he is a member of the great and powerful organisation known as the United States Soil Conservation Service which is armed with wide powers over the farmers. I understand that he is not a forester and it will be noted that his report does not mention a single species of tree or shrub. I mention this to emphasise that it is the view of the U. S. Soil Conservation Service that erosion problems cannot be tackled successfully by the experts of one department

alone—the agriculture, animal husbandry and engineering departments are concerned as well as the forest department.

I shall now give more detailed comment below on Dr. Shuhart's proposals.

Dr. Shuhart's Report

The report may be summarised as follows :—(I have repeated *verbatim* Dr. Shuhart's own words so far as possible).

(*a*) Some of the most severe erosion witnessed in all India was observed along the borders of the Jumna and Chambal rivers.

(*b*) The area is so highly eroded that it should not be grazed at all. The incidence of grazing allowed by the forest department in their demonstration areas is two acres per cow. It should certainly not be greater than ten acres per cow.

(*c*) The proper land use for these areas is fuel production. An excellent example of what can be produced in these gullied areas was observed near Etawah where for some 34 years the foresters have attempted to develop a fuel and forage reserve. In this demonstration it has been found that the *kankar* areas interfere with the proper growth and development of trees. But in this demonstration too, the demands of the people for grazing of livestock have almost ruined the erosion control value of the demonstration.

(*d*) Control of head erosion in these gullied areas cannot be accomplished by vegetation alone. The whole *erosion system* or unit must be dealt with and this includes a strip of the upper level cultivated lands which are the sources of water which cause the gullies. If this water continues to flow off uncontrolled head erosion will continue to extend. We must first conquer the heads and halt the extension of the gullies into the upper cultivated lands.

Cultivation should not be permitted near the overfalls at the head of the gullies and further back a system of contour farming including contour *bunding* should be practised.

(*e*) Control measures should include gully plugging, building the first dam near the top of every high point on the relatively level plain and progressing downward with successive *bunds*. If it is necessary to conduct excess run-off water, high velocity channels or necessary overfalls should be constructed.

(*f*) Cultivation of steep and rough areas in the ravines should not be practised. Cultivation should only be attempted in the broad *nalas*.

Comments on the report

Ref. (*b*)—The forest department are only too aware of the fact that the incidence of grazing is far too high and we have only allowed this incidence under severe local pressure. In actual practice the incidence is much higher than stated as 10 to 30 per cent. of the ravine area is inaccessible to cattle. As a result, Mr. Ford Robertson, I. F. S., reports that erosion is once more active even in the forest department demonstration areas. We must convince the villager that grazing control is in his own interests and we could only lower the present incidence gradually. I do not think we shall ever achieve the incidence of 10 acres per cow suggested by Dr. Shuhart. We have already demonstrated in our own experiments that a simple system of seasonal closure every other year in the monsoon compensates in considerable measure but a lower incidence must also be gradually aimed at. The grazing problem is so difficult in India that we think nothing will be achieved here except through *panchayats* of the villagers themselves.

Ref. (*d*)—I consider this one of the most important lessons to learn from the report and it is a feature of erosion control technique which we have neglected. The following is quoted from a note by Mr. Ford Robertson, I.F.S., who has been in charge of the Etawah area and who has recently studied soil conservation technique over a wide area of the United States :—

"I agree that our reclamation measures have not been sufficiently *extensive*, *i.e.*, they must be applied not only to the ravine area but to the more or less level land beyond and outside them. Gullies are essentially *symptoms*, the disease must be tackled in the land around and above them. Translating this into practical terms for the Doab, it means that we must avoid trying to reclaim only a *portion* of a ravined area (like Sarangpur *tora*) or even an entire ravined area minus its cultivated head waters (like Bateswar) and instead acquire a whole *erosion system* or *unit*. Gullies are like snakes—conquer the head and you can conquer the whole. Government's first care should be to halt the growth of the gullies which are eating into the valuable uplands and then stabilise and eventually make productive the eroded area in their wake. Actually, both phases can be and generally are tackled simultaneously. Here lies the weak spot in the forest department's work in the past. We treated ravines rather than headwaters."

This agrees with Dr. Shuhart's remark that "control of head erosion in these gullied areas cannot be accomplished by vegetation inside the gullies".

Except in the Fisher Forest we are not controlling the heads of the gullies and the obvious inference is that we should extend the

acquisition of land in the other forest department areas to include the heads of the gullies and a strip of the uplands above them and between them.

Ref. (*e*)—We have always realised the need of gully plugging. On the upper side of each *bund*, where a pool of water collects in the rains, silting occurs and in a year or two a flat broad bed of rich loam occurs, very suitable for tree growth.

The amount of *bunding* required varies considerably with the nature of the ravines. For example, 250 acres in the Fisher Forest were adequately plugged with 83 bunds in 1914. Again in 1919, in Bindwakhurd plantation, 24 *bunds* were made in 108 acres. Water escapes were made.

We sometimes made the mistake of making too few and making them too big—a large number of small *bunds* is more effective than a few big ones.

Dr. Shuhart emphasises that *bunding* should begin right at the top on the level cultivated lands.

Ref. (*f*)—Dr. Shuhart states that it may be possible to develop cultivation in the broad *nalas* so long as each *bund* for each individual field is properly developed and well established before the next successive field below is attempted.

Lack of knowledge and experience of Indian conditions has led him into an inconsistency here. The report emphasises that the ravine tract is so highly eroded that it should not be grazed at all. As we all know, cultivation in India without cattle is impossible.

Regarding this Mr. Ford Robertson comments "Under prevailing Indian conditions, I have no hesitation in saying that no reclamation scheme has a chance of succeeding in the Doab ravines if cultivation is to be admitted—it would be like darning a sock that has moth in it." Mr. Chaturvedi's comment is "Broad valleys being few and far between, the advisability of introducing scattered cultivation with its own complement of cattle, in ravines where erosion is rampant, is difficult to appreciate. In a locality where scarcity of fuel is so acute as to divert farmyard manure to village hearths, the cultivation of flat bottoms where tree growth is best, is, to say the least, a counsel of despair, *pace* the grow-more-food campaign".

I fully agree with these comments and on this particular point we cannot accept Dr. Shuhart's recommendation even with its careful provisos.

COWDUNG ECONOMY *VIS-A-VIS* CHARCOAL INDUSTRY

By K. P. Sagreiya, I.F.S.

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Part I

There is more or less general agreement, at any rate amongst those who are sympathetically inclined towards the agriculturists and are out to help them ameliorate their condition, that in the Central Provinces & Berar cowdung is being utilised as fuel out of sheer necessity and that given a cheaper alternative fuel it is bound to be used for manurial purposes to an increasing extent. The somewhat theoretical controversy regarding the wisdom or ignorance of the peasantry might therefore be shelved and attention directed to other aspects of the problem.

Besides the question of reforesting depleted forests and foresting wastelands *de novo*, the other most important question before the country is the rational utilisation of the existing supplies of fuel to divert larger quantities of cowdung for manurial purposes. Wider use of electric power, gas or even mineral coal are yet a far cry but the use of wood charcoal is definitely on the increase. The largest proportion of this is consumed in urban areas chiefly in big towns such as Bombay, Delhi, etc. to which large quantities are being imported mostly from the Central Provinces. It is therefore natural to ask what repercussions such export trade is having, or is likely to have, on the supplies of firewood to the local population which has to be weaned of the habit of using cowdung as fuel. It is this aspect of cowdung economy that has been examined in this note. A few remarks are also offered on the connected subject of prevention of over-exploitation of the private forests of the province.

If statistics were to be compiled it will be found that soon after the last war started, exports of charcoal from the Central Provinces suddenly shot up. They have steadily increased ever since and even after the cessation of hostilities the demand has not abated nor the prices declined.

It is estimated that something like 160,000 tons of charcoal is annually exported from the northern part of the Central Provinces, mainly to Bombay and Delhi, mostly from Khandwa, Hoshangabad, Betul, Saugor and Jubbulpore districts and to a less extent from Chanda Chhindwara, Seoni, Balaghat and Mandla districts.

It is sometimes assumed that charcoal manufacture for export purposes is confined to forests within 10 to 15 miles from rail-heads. It is therefore necessary to point out at the outset that this is not a correct statement. Charcoal is now manufactured in forests far in the interior and profitably marketed, as it can be cheaply transported in gas-driven trucks. Any one who doubts this has only to examine the results of recent auctions when reserved forests as far as 40 miles away from the nearest rail-head were sold at 200 % of the normal (pre-war) prices mainly for manufacture of charcoal to meet the export demand.

This sudden rise in prices and consequent tapping of the reserved forests farther and farther from the rail-heads has sometimes been attributed to the apprehended control of private forests and the contemplated ban on their exploitation for meeting the export demand for charcoal, as a measure of soil conservation. This is however only partially true. The main reasons are :—

(*i*) the unlimited demand in Bombay and Delhi and the very high prices ruling there,

(*ii*) the rapid disappearance of all private forests and the recent clear fellings of the reserved forests from the vicinity of rail-heads,

(*iii*) the policy of forest conservation adopted by the Bombay Government, and

(*iv*) the assurance given by the Bombay Government to C.P. contractors that all facilities will be given to them for exporting whatever charcoal they can manufacture.

It may here be pointed out that the fixing by the C.P. Government of a ceiling price of Rs. 2,000 per bogie-load (40 tons) of charcoal exported, and of Rs. 3/- per *maund* for local sale, primarily with a view to make charcoal available for local consumption, did not have the desired effect. It is common knowledge that when contractors are paying as much as Rs. 700 as royalty on forests producing one bogie-load of charcoal, and the cost of manufacture and transport to the consuming centres is as high as Rs. 1,200 the local exporters are getting much more than the ceiling price. The reluctance of these exporters to sell charcoal locally at the ceiling rate, is proof positive that they are reaping far higher profits than those contemplated under the ceiling rate.

Be that as it may, this much is a fact that the export demand is unlimited and in spite of high wages the contractors find charcoal making a lucrative industry.

The question that will naturally occur to any one who has the welfare of the local people at heart is, "How far such exports of charcoal are beneficial to these people who, as it were, live symbiotically with the forests ?"

The main arguments in favour of fostering this industry are :—

(*i*) It gives large profits to forest-owners and hence directly or indirectly to Government which can ill-afford to forego such revenue, when it is badly needed for financing nation-building activities, especially as it is faced with a heavy drop because of its policy of prohibition.

(2) It gives employment to a large number of persons and thus relieves unemployment to a great extent.

(3) It ensures fuller utilisation of the forest growth and a ready market for remote forests, because charcoal can stand longer distance transport than firewood.

(4) It meets the genuine demand of a neighbouring province.

These arguments conveniently ignore certain vital facts on which primarily depends the furture well-being of the people of the province.

These are :—

(1) The unlimited demand and the incomplete control over fellings in the private forests are resulting in their over-exploitation without any regard to regeneration. This is hastening soil erosion.

(2) The lucrative export trade in charcoal is raising the price of firewood, when the policy should be to make it available to the local people as cheaply as possible to wean them of the habit of burning cowdung which is so necessary for manurial purposes.

(3) The 'dry' method of making charcoal all over the forest—a method of recent introduction—coupled with clear fellings, is having a detrimental effect on the regeneration of the forests, a fact which has not yet been sufficiently realised.

(4) Over-fellings expose the forest soils which soon get dry and pulverised. The humus and the top soils are thus washed away in the first heavy monsoon shower exposing the coarser subsoil which does not hold the rain water and thus allow it to seep through. Floods are thus caused. The silt-laden water when flowing over agricultural lands in the lower reaches leaches out the soil of essential chemicals and the silt on sedimentation clogs it and hampers drainage. The subsoil flow of water in the upper regions is also decreased owing to lesser percolation and thus the growing season of agricultural crops which is governed by the subsoil moisture made available to plants by capillarity action is shortened. Poorer crops are the result. In short, an economic regression of both the forest and the field crops sets in.

(5) Clear fellings followed by heavy grazing and fires take a heavy toll of forests seedlings, and thus the forests are steadily becoming more and more xerophytic and depleted.

(6) Encouragement of the charcoal industry is the very antithesis of the policy of creating fuel forests. The latter is the prime need of the hour to popularise the use of cowdung as farmyard manure.

(7) The lion's share of the profits of the charcoal industry goes to contractors most of whom are 'birds of passage'. What little the forest-owners get is but a temporary gain at enormous future loss to the province.

In short, the policy of encouraging export of charcoal to augment revenue, might well be compared to the satisfaction that the dog of the parable got by licking a dry bone until his tongue got lacerated and began to ooze blood. He went on sucking his own blood, all the while feeling that it came out of the bone!

It is therefore absolutely essential, in the interest of agriculture—which is the main industry of the province—to curb this unhealthy demand. The best procedure will be to earmark forests which could be utilised for producing charcoal for meeting the reasonable export demand and then to work out their sustained annual cut.* These should then be leased out to the highest bidders, who should be allowed to sell their charcoal *outside the province* at the maximum price obtainable. This will not only augment local supplies but will also give far higher profits to Government. Unless such action is immediately taken, the day is not far distant when C. P. too may become as fuel-starved as the plains of the Punjab or the U. P. are. What is worse, as all of the rivers having their source in the province flow away from it, not only will the watershed be completely denuded in course of time but this will also result in disastrous floods in the neighbouring provinces. One can clearly see the writing on the wall.

Part II

The question of prevention of over-exploitation of the private forests, which cover nearly 25% of the area of the province, is interrelated with the consideration of cowdung economy *vis-a-vis* charcoal industry. A few remarks will thus not be out of place.

Over-exploitation of the forest growth on the lands of private estates of the province is at present prevented or rather attempted to be

* Roughly eight to 10 acres of reserved forest and 30 to 40 acres of the average private forests yield one bogie of charcoal. The minimum rotation on which they can be worked is 40 years.

... nted by the rules made by the Provincial ...ernment under Section 202 of the C. P. L..nd Revenue Act. These rules purport to regulate the control, management and the exercise of the right of user over such growth. This section and the rules made under it are:—

Section 202.

(1) The Provincial Government may make rules regulating the control and the management of the forest growth on the lands of any estate or mahal, and the exercise of any right of user over such forest growth and may attach to the breach of such rules a penalty not exceeding one thousand repees, or if the breach be a continuing one, a penalty not exceeding ten rupees for each day during which such breach continues.

(2) The Deputy Commissioner may direct that the whole or any part of any sum recovered under the rules made under sub-section (1) shall be paid as compensation to any person or persons to whom loss or injury has been caused, or that it shall be expended in such manner as he may deem fit for the benefit of the forest growth.

(3) The Deputy Commissioner may confiscate and sell any timber or other forest produce cut or removed in contravention of any rule made under sub-section (1), and may apply the proceeds of sale to either or both of the purposes mentioned in sub-section (2).

(4) If the proprietor or any other person is guilty of any material violation of the rules made under sub-section (1), the Deputy Commissioner may, unless he is satisfied that the proprietor has taken reasonable precaution to prevent such violation and after full enquiry by him and after giving the proprietor an opportunity to explain:—

(*a*) proclaim that the forest growth of the estate or mahal will be protected by Government; or

(*b*) issue notice to the proprietor to show cause, within a reasonable time to be specified in the notice, why he should not be excluded from the possession of the forest land.

(5) Until proclamation made under sub-section (4), clause (*a*), is withdrawn, it shall be unlawful for any person to cut or cause to be cut, for sale or for conveyance or use outside the village area, any timber, bamboos or brushwood, save with the previous sanction of the Deputy Commissioner and in the manner and to the extent permitted by him.

(6) If no sufficient cause is shown against an order under sub-section (4), clause (*b*), the Deputy Commissioner may exclude such proprietor from the possession of the forest land and assume the direct management thereof for a term to be fixed by him.

(7) The costs of management shall be payable by the proprietor, or by the superior and inferior proprietors in such proportions as the Deputy Commissioner may direct.

(8) The profits of such forest land, while under direct management, shall be paid to the proprietor or to the superior and inferior proprietors.

(9) No lease, lien, incumbrance or contract with respect to the forest land held under direct management shall be binding upon the Crown.

(10) On expiration of the period fixed for the direct management, the forest land shall be restored to the proprietor thereof.

Explanation :—

In this section "proprietor" includes a transferee of proprietary rights in possession, a *thekadar* or a headman with protected status, a mortgagee with possession and lessee holding under a lease from year to year or for a period exceeding one year, but not a *malik-makbuza*.

Notification No. 529-2095-XII, dated 10-2-32 as, amended by Notification No. 2765-1739-XII, dated 23-8-34 and Notification No. 893-5654-XII, dated 9-3-39.

In exercise of the powers conferred by sub-section (1) of Section 202 of the Central Provinces Land Revenue Act, 1917 (II of 1917), the Governor-in-Council is pleased to make, after the previous publication, the following rules to regulate the control and management of forest growth and the exercise of any right of user over such forest growth in estates and mahals, in supersession of those published under Notification No. 585-1167-B, dated the 24th December 1918:—

I.—General.

1. In these rules the term "forest growth" shall mean forest growth growing on land classed as forest land, waste land, or scrub jungle in the record of rights relating to any estate or mahal and shall include trees self-sown or otherwise. The term shall not include forest growth growing on the occupied area or village site of any estate or mahal.

2. Trees of the following species in forest growth shall not be cut without the previous permission of the Deputy Commissioner:—

Mango, tamarind, *mahua*, *achar*, *jamun*, *harra*, *bahera*, sindhi-palm, palmyra palm and the fruit-bearing *tendu*.

3. (1) A proprietor shall not give nor shall any person take a lease of any land containing forest growth without the previous permission of the Deputy Commissioner.

(2) Subject to rule 2 and subject to any prohibitory order made by the Deputy Commissioner under rule 4, the proprietor of any estate or mahal may, either himself or through his tenant, lessee or licensee, cut and dispose of the forest growth on any land for the purpose of clearing it for cultivation.

Provided that the proprietor shall give 6 months' notice in writing to the Deputy Commissioner before any clearing operations, either by himself or any other person, are started.

Provided, further, that the Deputy Commissioner may exempt any estate or mahal from the provisions of rules 2 and 3.

4. If, when permission is applied for under sub-rule (1) of rule 3 or on receipt of the notice referred to in first proviso to sub-rule (2) of rule 3 the Deputy Commissioner considers that it is desirable, in the public interest or in the interest of persons who by custom or by virtue of any entry in the village administration paper prepared under section 79 of the Act enjoy any right of user over the forest growth, to refuse permission to the branch of the lease or to prohibit the clearing of the land for cultivation, he may, for reasons to be recorded in writing, refuse such permission or, prohibit such clearing.

5. (1) If the land is not required for cultivation, the cutting and disposal of forest growth shall be subject to the following conditions, in addition to that prescribed by rule 2:—

(*a*) No *dahia* or *bewar* cultivation shall be permitted, except in area specified by the Deputy Commissioner.

(*b*) In cutting timber trees, seed-bearing trees at a rate of not less than 30 per acre of the principal kind cut shall be left; and the total number of trees of all kinds left standing shall not be less than 90 per acre, evenly distributed over the area in which cutting is effected.

(*c*) Timber and brushwood shall be cut flush with the ground.

(*d*) In cutting bamboos all culms of less than two years' growth shall be left in the clump.

(e) No cutting shall be done within 20 yards of either bank of a stream which ordinarily retains water until January.

(f) No trees shall be ringed for resin so as to sever the bark round the entire circumference, and no tree shall be deprived of so much of its bark as is likely to cause it to die.

Notification No. 1797-XII, dated 6-5-36.

5. (2) No lease or licence for the unrestricted cutting of live timber over the whole or any specified part of the area covered with forest growth in a village shall be granted without the permission in writing of the Deputy Commissioner, who shall satisfy himself that the condition of the forest and the terms of the lease or licence are such that the grant of the lease or licence will not lead to the destruction or permanent deterioration of the forest or to the destruction or permanent infringement of the rights of user enjoyed by co-sharers and tenants in the forest growth.

NOTE.—Licences in writing for the extraction of limited quantities of timber may be granted without permission, subject to the provisions of rule 5, provided that they are not issued in such numbers and for such quantities as seriously to injure or diminish the *nistar* enjoyed by villagers entitled to it.

II.—Rules After Action Under Sub-section (4) (a) Or Under Sub-section (6) has been taken.

6. When the Deputy Commissioner has, under sub-section (4) (*a*), proclaimed that the forest growth of any estate of mahal has been taken under the protection of Government, he shall record an order stating the restriction imposed on the cutting of the forest growth, and one copy of this order will be given to the proprietor and another shall be posted in a prominent place in the village. If the order concerns the forest growth of an estate, copies of the order shall be posted in the chief villages of the estate.

7. Such order shall permit the removal of leaves, grass and dead wood, and the cutting of such timber as is required for the domestic consumption of the proprietor and of the persons entitled to use of the forest growth under the terms of any village administration paper. But the Deputy Commissioner may limit such cutting for *nistar* if he considers such limitation necessary for the preservation of the forest growth.

8. When the Deputy Commissioner has, under sub-section (6), assumed the direct management of the forest land of a mahal or estate, it shall be managed so as not to interfere with the customary rights specified in rule 7.

III.—Penalties.

9. Any proprietor or other person who—

(*a*) cuts any tree of the species enumerated in rule 2 without the permission of the Deputy Commissioner,

(*b*) omits to take the permission required under sub-rule (1) of rule 3 or to give the notice prescribed by the first proviso to sub-rule (2) of rule 3,

(*c*) occupies any land in respect of which the permission as aforesaid has not been obtained or clears any land in respect of which the notice as aforesaid has not been given,

(*d*) occupies or clears any land contrary to an order made under rule 4,

(*e*) commits any breach of rule 5,

(*f*) cuts any forest growth not permitted by an order made under rule 6 or rule 7, when the forest growth of the estate or mahal has been declared protected, or,

(*g*) cuts any forest growth of which the Deputy Commissioner has assumed direct management without the permission of the Deputy Commissioner or of a person authorised by him, shall be liable, on the order in writing of the Deputy Commissioner, to a penalty not exceeding one thousand rupees, or, if the breach be a continuing one, to a penalty not exceeding ten rupees for each day during which such breach continues.

NOTE.—A proprietor shall not be liable for any breach committed by any other person unless he has abetted such breach.

IV.—Working Plans.

10. Any proprietor shall be at liberty to submit to the Deputy Commissioner a working plan for his forest lands or to apply to the Deputy Commissioner to have a working plan prepared by Government at his expense, and on such a plan being approved by the Commissioner, the forest lands shall be deemed to be exempt from the operation of the foregoing rules during the currency of the plan and so long as its provisions are observed.

11. If no sufficient cause is shown against an order under sub-section (4), clause (b), the Deputy Commissioner may, instead of excluding such proprietor from the possession of the forest lands, offer him the alternative of having a working plan prepared by Government at his expense and of binding himself to abide by its terms.

FORM OF NOTICE UNDER RULE 3 (2)

Name of proprietor	Name of estate or mahal in which it is proposed to cut timber	Estimated area of forest	Area which it is proposed to clear for cultivation with description of soil	By whom the land when cleared is to be cultivated	Estimated number of timber trees to be cut with specification of species of trees
1	2	3	4	5	6

A critical examination will show that these rules are not quite effective in preventing over-exploitation.

It will be seen that (vide rule 2) the previous sanction of the Deputy Commissioner is required for cutting only mango, tamarind, *mahua*, etc. all of which are primarily prized for their fruit, flower or juice. It would thus appear that the restrictions under this rule were primarily intended to maintain an adequate supply of these minor forest products. The list does not include any of the common timber and fuel trees, nor species which are also utilised by the population, such as bamboos, *ber* (thorns used for fencing) *palas* (for lac propagation), *pipal* (for fodder), etc.

In other words, a proprietor is free to exploit the unspecified species more or less completely, as and when he desires whenever he wants to clear any land for cultivation, albeit temporary; provided that he gives 6 months' notice in writing to the Deputy Commissioner. Even this notice or the retention of specified fruit trees is not necessary in the case of estates exempted by the Deputy Commissioner. There is thus no check on destructive fellings for temporary, *bankheti* which means that rule 5 can be rendered inoperative.

The Deputy Commissioner can prevent such exploitation only if he considers it desirable in public interest or when any persons by custom or an entry in the *Wajib-ul-arz* enjoy any rights of user over the forest growth.

In rare cases, when even temporary cultivation is not possible, the only restriction imposed on excessive fellings is the leaving of 30 seed-bearing timber trees of the principal kind and at least 60 other trees, per acre, evenly distributed.

It should be noted that the phrase *timber trees of the principal kind* has not been defined, except that they should be *seed-bearing*. Even saplings can bear fertile seed and thus all larger trees can be cut down and the letter of law satisfied by leaving the requisite number of saplings. Ninety such saplings per acre and such coppice growth as might appear, cannot preserve the factors of the locality and ensure regeneration. In fact with such drastic fellings and subsequent heavy grazing, fires and ruthless shrub-cutting, the area soon ceases to be a forest in the scientific sense of the word. One has only to inspect the areas felled during the last war to take advantage of the charcoal boom to be convinced how a forest can be devastated. In certain parts even *palas* trees have been burnt for charcoal which has been used for adulteration by soaking it in water! The exposed soil will soon get devoid of humus and the chances of natural reforesting will be reduced to nil. The vestigial tree-cover will disappear and the area colonized by xerophytic and unpalatable shrubs such as *Lantana*, *Gmynosporia*, *Carissa*, or weeds like *Xanthium strumarium*, *Acanthospermum*, etc. and hemicryptophytic and coarse grasses like *Apluda*, *Themeda*, etc. In short rule 5 cannot prevent a retrogressive plant succession from a well-stocked forest, to thorny-scrub.

If any proprietor is found to be guilty of infringing the rules, under rule 6 the Deputy Commissioner can take the forest growth under protection, but even then vide rule 7 the proprietor and the right-holders are entitled to remove for their domestic consumption leaves, grass, deadwood and even timber to an *unspecified* extent. Thus, much harm can be done to an understocked forest. The safeguard, under rule 8, of restricting the removals in the interest of preservation of the forest growth is vague and in practice seldom used.

In the event of serious violation of the rules the Deputy Commissioner can assume *direct man agement* only of the *forest land i.e.* excluding *wasteland* and *scrub jungle*. Thus no anti-erosion measures can be enforced on lands belonging to the latter categories which need them most. Because of this loophole, the existing waste land and scrub jungle cannot be reforested and they are steadily deteriorating. Before long they will get so depleted that it will not be possible to reforest them economically or at any cost.

The penalty imposed for an established breach of rules namely a lump sum of Rs. 1,000, of Rs. 10 per day, is not deterrent enough in these days of high prices of charcoal and timber.

A subsidiary, but by no means a negligible, cause of the steady deterioration of the private forests is the inability of the Deputy Commissioner or his technical forest advisers to frequently inspect the private forests. Unscrupulous proprietors have taken advantage of this.

The only provision under which over-exploitation could be successfully prevented, is rule 5 (2) inserted in 1936. But unfortunately

the excellent provisions of this rule have been diluted down by the footnote under it. Many a forest has been ruined because of this loophole.

Lastly, there is the provision in the rules under which a proprietor is at liberty to submit to the Deputy Commissioner a working plan for his *forest lands* (*i.e.* exclusive of *waste land* and *scrub jungle*), or to apply to him to have a working plan prepared at his expense. Once such a plan has been approved by the Commissioner the forest land is deemed to be exempt from the operations of section 202 so long as the prescriptions are not revoked. This pre-supposes a careful scrutiny of the prescriptions to see that they will prevent over-fellings. Cases are on record when this was not done.

When an order under rule 4 (2) has been issued against a proprietor the Deputy Commissioner may ask him to get a working plan prepared at his (the proprietor's) expense and to abide by its prescriptions.

This extreme step is by far the best measure for successfully preventing over-exploitation provided the working plan is carefully prepared. The underlined provisions of the prescriptions should be—

(*i*) to conserve all financially immature growth after giving it the optimum growing space, and to remove only that mature growth the retention of which is not necessary from the silvicultural and soil conservation points of view.

(*ii*) to safeguard the regeneration, and thus perpetuate the forest in a condition suited to the needs not only of the proprietor but also of the people as a whole.

In other words the prescriptions should aim at increasing the productivity of the forests and at obtaining indirect benefits from them by removing all unwanted financially mature growth as fast as possible and restocking the growing space thus set free by productive growth that will preserve, and where possible, improve the factors of the locality.

This could be achieved to a very great extent by amending the existing rules made under section 202 as indicated below :—

Rule 2. The list should include the principal timber and fuel yielding trees also.

Rule 3. Before cultivation in Sub-rule (2) insert "permanent".

Rule 4. A footnote should make it clear that soil conservation and checking of erosion damage are measures of public interest.

Rule 5. When land is not cleared for cultivation, *i.e.* when a forest is to be perpetuated, the minimum amount of vegetative cover that must be left (excluding the problematic re-growth) should be precisely laid down, to ensure the preservation, and where possible improvement, of the factors of the locality and to get adequate regeneration of species of economic and silvicultural importance. This rule should, therefore, be drafted in consultation with the Forest Department. Perhaps the safest and the simplest prescription will be to fix the minimum basal area per acre, of dominant trees of specified species that must be left uniformly spread over the forest. This should be fixed with due regard to regeneration and soil conservation.

Rules 7 & 8. It should be provided that the Deputy Commissioner may prevent removal of *any* produce from forests which are likely to get depleted by such removal, and then direct the right holders to obtain them from another area.

Rules 10 & 11. It should be emphasized that the main criterion for approving the working plan should be that its prescriptions will perpetuate the forest and where possible increase its productivity and utility to the people.

Part III

So far the question of preventing over-exploitation of the private forests under Section 202 of the Land Revenue Act was discussed, and its main drawbacks pointed out. Over-exploitation can also be prevented under the provisions of the Indian Forest Act, as indicated in the paragraphs that follow.

Prevention of over-exploitation of private forests is a matter of public interest, as the

forest policy definitely lays down that forests are needed—

(*i*) to preserve the climatic and the physical conditions of the country, and

(*ii*) to promote the general well-being of the people.

Private interests and rights must thus give way as far as necessary when public interests are involved.

Under section 35 of the Indian Forest Act the Provincial Government can by a notification in the local official gazette prevent over-exploitation by regulating or prohibiting in any forest land or waste land,

(*a*) the breaking up or clearing of land for cultivation,

(*b*) the excessive pasturing of cattle whereby either existing forest is endangered or such as has already disappeared is prevented from growing up again,

(*c*) the burning or cutting down of the surface growth (even when it cannot be called forest) when such measures are considered desirable,

(i) to minimise soil-erosion or mitigate floods,

(ii) to conserve the soil and maintain its fertility,

(iii) to regulate the water supply,

(iv) to protect the lines of communication, and

(v) to preserve public health.

When such restrictions are considered necessary, a notice is first to be issued calling on the proprietor to show cause within a reasonable time, why a notification declaring the necessity of the case and the particular remedy required should not be issued. The objections and evidence in support of them, if any, offered by the proprietor are heard by an officer especially appointed for the purpose, who records his opinion and then submits it to the Provincial Government for 'consideration'. If the Provincial Government decide against the objection, should there be any, a notification is issued in the local official gazette specifying the limits of the tracts and declaring the prohibitions, regulations, etc., that are called for. If, however, prohibitions are not sufficient to effect the purpose required, without protective works, the cost of these must be borne by the Government.

When regulations ordered or the prohibitions imposed are neglected or flouted and the objecttive of Government cannot be achieved, the lands may be taken under the control of a forest officer and subjected to all or any of the provisions relating to Reserved Forests under Section 36 of the Indian Forest Act.

Lastly, if absolutely necessary, Section 37 provides that Government could acquire the land under the Land Acquisition Act, 1894.

Where a notification under Section 35, has been issued, if Government interference is kept up for three to twelve years the owner may require Government to acquire the land.

Any proprietor can under Section 38 apply to Government to place his lands under forest management or to apply any provisions of the Indian Forest Act to it, but Government is not bound to comply except so far as it thinks proper.

Part IV

The tree-growth over Government *waste lands* could also be protected and the stocking improved under the Indian Forest Act. The general right of Government to unoccupied waste lands is sufficient to enable it without any hardship to the public, to constitute large state forests for the public benefit. The common rights of the people, if any, can be brought out or otherwise provided for by the various means prescribed by the Forest Law.

Lastly, vide Section 83 of the Indian Forest Act, whenever it appears to the Provincial Government that any land is required for any of the purposes of this Act, such land can be deemed to be needed for a public purpose within the meaning of the Land Acquisition Act, 1870, Section 4.

FARM FORESTRY *

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Introduction

FARM FORESTRY has been defined as the practice of forestry on farm lands generally more or less integrated with other farm operations.

From the economic point of view every farm should be self-supporting for its fuel and timber, grazing and fodder for its animals, and manure leaf for its fields. Every farm is also dependent on the indirect benefits of forestry for its protection against damage to the crops by winds whether hot, cold, or dessicating, or destruction by storms and the hail and snow they bring with them, and against erosion whether sheet erosion by wind or gully erosion by water.

A balanced farm forestry policy is important in lands and climates which are completely suitable for agriculture but it becomes of vital importance in what is commonly called marginal farm land, *i.e.*, the lands and climates which are doubtfully suitable for permanent agriculture and where bad farming and lack of land management may exhaust the soil and render it unfit for cultivation in a comparatively few years. This process is usually accompanied by wind and water erosion and the last stage may even be desert. The more developed the country is, the faster this deterioration takes place, and we have before us the extreme example of the 'dust bowl' of the U. S. A. where in a few generations intensive farming and lack of land management turned a million square miles of fertile farm land into a wind blown desert.

Much of India's agricultural land consists of such marginal land particularly in the low rainfall areas of the north west, but so far little attention has been paid to farm forestry and many is the example of land going out of cultivation through lack of land management. Some of it recovers a little of its fertility after years of fallow but much of it has deteriorated to such an extent that it is permanently out of cultivation and a menace to other areas which have not yet reached the same stage.

Farm forestry thus consists of the management of shelter belts, wind breaks and live hedges for protection and fuel, small timber, fodder and manure leaf plantations, etc., for production.

Percentage of Woodland on the Farm

One of the first questions that arises is that of how much of the farm should be under tree growth. This of course depends on the type of farm and the soil and climate of the area and is a subject that has been much debated, but in European countries and America the general average opinion is about 10 per cent to 20 per cent. In India the position if somewhat different for it is a warm climate and the quantities of fuel and timber required are therefore smaller. I have discussed this question with a number of progressive and experienced farmers in India and the consensus of opinion is that first of all, all land on the farm that is not fit for agriculture should be put under forest and secondly that all road sides and water channels should have their avenues and shade trees. If this is done completely then if some 5 per cent. of the remainder is under the tree growth it is sufficient. One *zamindari* of 17,000 acres in S. E. Sind which grew wheat and cotton was nearly self-supporting for fuel by using the cotton stalks. On this farm, roads and water channels were well-forested and in addition some 3 per cent of land under forest was found to be sufficient.

Shelter Belts and Wind Breaks

In many parts of the country farms have to be protected against winds and storms. These winds and storms may damage the crops by being hot and dessicating, or cold and freezing, they may bring hail or snow which does physical damage, or they may cause serious surface sheet erosion by blowing away the top soil.

Shelter belts are wide belts of tree growth which go right across the land and give a general protection usually against wind erosion while

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wind breaks are narrow strips which give local protection generally of a particular kind against a particular danger.

So far as policy goes my view is that the broad shelter belt is the responsibility of the government or state except in the case of very big agricultural estates, and the narrow wind break, giving as it does local protection, is the responsibility of the land owner. Thus the shelter belt with its revenues in most cases going to the province or state tends to become part of the protection forests of the state, while the wind break with its revenues going to the land owner is the essential of farm forestry.

The general benefits of shelter belts and wind breaks are :—

(1) They protect the growing crops as well as livestock and man from cold and from hot parching winds.

(2) They prevent the soil from drying out rapidly.

(3) They check erosion by wind (*i.e.* the blowing away of the top soil).

(4) They provide wood products for farm use and for sale.

(5) If of sufficient area they provide grazing for farm animals.

(6) They provide shelter for animals and birds and also for insects that fertilise the flowers of the forest trees and crops.

(7) They beautify the farm and make it more livable.

Several disadvantages are often raised against shelter belts and wind breaks and the chief of these are :—

(1) they take up land that often might be more profitable under crops,

and (2) that by their shade and root competition they reduce crop yields in their immediate vicinity.

These are often prejudiced opinions in which the unseen benefits of the shelter are not taken into account. Crop increases are often spectacular because of the shelter and for stock the shelter may be a matter of life or death. For the people living on the farm lack of shelter may lead to malnutrition.

The degree of effect of the shelter belt on the crop yield of course depends on the climate of the year. This is illustrated by experiments made over many years in the dry zone of south Russia where the effect of the shelter belt caused an increase in crop yield in favourable years of 10 to 15 per cent, in years of moderate drought of 50 to 70 per cent, and in the years of severe drought of 100 to 150 per cent.

I have discussed this point with many people and as far as I know no experimental data exists in India. Two expert opinions which should carry weight under Indian conditions are firstly officers of the agricultural department in the Deccan expressed the opinion that with the small fields in vogue, if every field boundary had one line of trees on it, root competition and shade would probably reduce the crop yield by some 3 to 5 per cent. Secondly in southern Sind I went round a 17,000 acre *zamindari* of wheat and cotton with the farmer while the wheat was three quarters grown. This farm is well forested and he expressed the opinion that the shelter of the trees probably increased the crop yield by some 5 per cent.

The sum of the conflicting effects of shade, shelter and root competition are thus local and must be determined for each locality and crop.

There is extensive literature on the subject but much of it is merely personal opinion or alleged experience, and comparatively little is based on carefully controlled experiments. Large-scale work has chiefly been done in Russia and the U. S. A. but Australia and parts of Africa and Europe have also contributed. Hungary, Canada, New Zealand, Ceylon, and Great Britain have also brought a great deal of practical experience to the problem.

A shelter belt being a broad strip of forest there is little to be said about its type or composition except that general opinion is that it should be at least 2 chains (132 feet) wide and preferably very much wider. The distance between successive belts depends entirely on local conditions but in the extreme case of the southern steppes of Russia it is given as some 500 to 1,000 yards.

The type of wind breaks depends on the nature of the danger to be guarded against and the crop to be protected. Three main types are however distinguished :—

(a) those impenetrable to wind throughout their height,

(b) those slightly penetrable below and impenetrable above,
(c) those partly penetrable throughout their height.

For protection against winds they should of course be at right angles to the wind they are intended to protect the crop against, and this is usually the worst wind and not necessarily the prevailing wind. They should also be planted along all road and water channels, and along the edges of gullies, ravines and streams to prevent water erosion.

One of the few cases of the use of wind breaks to be seen in India is the protection of fruit crops in the United Provinces and Punjab by a single line of *Eugenia jambolana*. These are usually not very good efforts for as the trees grow up, natural pruning renders them penetrable for about two thirds of their height. Even so they protect to some extent the actual blossom and fruit. In some cases they have a mud wall or a line of aloe and high grass at the foot but even so they are generally almost completely penetrable in their middle section.

Under general Indian agricultural conditions fields are so small that wind breaks will have to be only one or two rows wide along the edges of the fields or contour *bunds* until such time as collective farming and larger fields and holdings come into being. One of the most suitable trees yet seen for most conditions is the fastigiate variety of *Acacia arabica* which if grown close and flanked on the windward side by firstly by a row of *Euphorbia* or *Agave* (aloe) or high grass such as *Eulaliopsis binata* and secondly by a row of a higher bush such as *Vitex negundo*, should be very effective. Species will of course vary with local conditions but if they are carefully chosen the high tree, the low tree and the bush or grass of the wind break will all give money yields. One essential must however never be forgotten *good silviculture is the basis of the raising and maintenance of efficient and paying shelter belts and wind breaks.*

Measurements of the effects of shelter belts and wind breaks vary very greatly with the type of belt and the local climatic conditions but a general average figure is that a properly designed shelter 2 chains (66 feet) high will give full protection for about 5 chains (330 feet) and partial protection for about 1,000 feet or roughly 15 to 20 times the height of the shelter.

Another generalisation is that a straight wind of 30 m.p.h. striking against a wind break 35 feet high results in confused air currents of 10 m.p.h. for 150 and of 15 m.p.h. at 200 feet on the leeward side.

Other beneficial effects that have been successfully demonstrated (chiefly in Russia) are: evaporation was reduced by about 40 per cent, the average soil moisture content down to 3 feet was increased from 1 to 2 per cent, the relative humidity was increased by from 1 to 5 per cent and the extreme of low humidity was raised by some 4 to 8 per cent.

The general question is admirably discussed by WEIR, A. H. W. (1945) Shelter belts, *Forestry abstracts* 6 (3). This publication gives a fairly comprehensive bibliography of which the majority of publications are in the library of the central silviculturist and available for reference.

For literature please also see MUNNS, E. N. (1940). A selected bibliography of North American Forestry, Vol. I. Wind breaks and Shelter belts. *Misc. Bull.* 364, U. S. Dept. of Agri. pp. 324-336.

Live Fences

For still more local protection live fences and hedges are very useful and also can be very profitable. Over large tracts of agricultural India one not only scarcely sees a tree but also very rarely sees a hedge. In Central India particularly one sees the precious top soil of the wheat fields blowing away in the wind where cheap, quick growing, live fences round the fields would do much to mitigate the damage.

The species and the methods of raising such a fence of course vary with local conditions but before deciding on the species to be used it is very necessary to consider carefully the objects for which the fence or hedge is to be raised.

Common objects of management, either separately or in combination are:—

(a) To keep out man.
(b) To keep out cattle.
(c) For demarcation purposes.
(d) To stop wind erosion.
(e) To provide some useful product such as fibre (Aloe), paper (certain grasses) or other minor forest product.
(f) For aesthetic reasons to make the farm more attractive and livable or to provide privacy.

The following is a list of species that have been used successfully for different purposes in different provinces. They have been grown chiefly in the drier districts :—

BOMBAY. *Euphorbia tirrucalli*, *E. neriifolia*, *Jatropha curcas*, *Synadenium grantii*. (The latter makes a very successful hedge and fence).

MADRAS. Very good. *Acacia arabica*, *A. planifrons*, *Agave americana*, *Azadirachta indica*, *Balsamodendron berryi*, *Bauhinia purpurea*, *Euphorbia quadrangularis*, *E. antiquorum*, *E. trigona*, *Prosopis juliflora*, *Zizyphus jujuba*. Good. *Dendro calamus strictus*, *Dononea viscosa*, *Inga dulcis*. Poor. *Circus quadrangularis*, *Euphorbia neriifolia*, *Poinciana alata*, *Protium candatum*.

PUNJAB. *Acacia modesta*, *Baccharis viminea*, *Gymnosporia montana*, *Inga dulcis*, *Ipomaea cornea*, *Ligustrum lucidum*, *Parkinsonia aculeata*, *Prosopis juliflora*, *P. glandulosa*, *Rhus lancea*, *Thevetia nerifolia*, *Vitex negundo*. High tufted grasses.

UNITED PROVINCES. *Agave* spp. *Carissa opaca*, *Cinnamomum camphora*, *Dodonea viscosa*, *Duranta plumieri*, *Furcraea* spp., *Gardenia*, *jasminoides*, *Hibiscus syriacus*, *Inga dulcis*, *Lawsonia alba*, Myrtle, Oleander, *Sesbania aegyptiaca*, *Tecoma stans*. High tufted grasses.

NOTE:—*Sesbania aegyptiaca* is short lived, *Dodonea viscosa* is difficult to maintain for more than 5 to 7 years. It is difficult to make a good hedge of oleander. *Lawsonial alba*, *Tecoma stans*, *Gardenia jasminoides* and *Duranta plumieri* all make very good hedges.

Attention is drawn to :—

BOND, W. E. (1945), Suitability of various hedge plants and live fencing poles in Northern Nigeria. *Farm and Forest* VI (1). pp. 22-26.

In this publication the author lists 14 species which he describes as 'shrubs or short plants' which are planted closely with the object of forming a hedge impenetrable to man and beast and 10 species of live stakes which are planted in rows usually not more than a yard apart and to which mats, stalks or com or wire can be tied to form a fence. On government farms these are used to support wire netting or wire, to form a stock and game proof fence.

This article is particularly interesting as the climatic conditions of Northern Nigeria are similar to those of parts of India and many of the species used are closely allied to Indian species.

The Farm Wood Lot

The above heading has been borrowed from the Americans and I use it to describe the plantations that are raised on farm land to supply the agricultural community with their needs of fuel, small timber, fodder, grazing, manure, leaf, etc., etc.

In his "Post-war forest policy for India", Howard (1944) said "The main difficulty over a large portion of India is to fulfil the legitimate wants of those villagers whom I have called 'ordinary village consumers' (and these are in the main agriculturists—*Author*) that is to say those who at present have no forest land anywhere near them to fulfil their wants. It is this vast number of ordinary villagers who cannot get sufficient forest produce for their minimum needs and of necessity use cowdung as fuel, the whole of which ought to be available for its more legitimate use as manure which constitutes the most pressing problem in the future forest policy of India............This small timber and fuel part of the problem will be the most difficult of solution. Even after a survey and a classification of all possible land available for this purpose it may be found that there is still insufficient land available for forestry to fulfil the minimum legitimate needs of the agricultural villager, and even if the area is sufficient it will be found that much of it at present contains no trees, is over grazed, and is under no management at all".

Since the above was written many different terms have been used, such as village forests, plantations or village waste lands, communal forests, co-operative society plantations, all of which really mean the same thing—the supply of the forest product needs of the agriculturist—whether they are on government waste-land, on land in the farm unfit for crops, or whether they are part of the farm land itself.

I therefore use the American term, the *farm wood lot* to describe them all.

Earlier, the percentage of the farm land that should be under forest has been discussed and it was pointed out that all road sides and water channels should be planted, all wasteland not fit for crops should be put under forest and finally if the total so obtained is not sufficient then a definite percentage of the actual crop land should be planted with trees. The total of all this should be somewhere in the neighbourhood of 10 per cent of the total area of the farm. In some parts of India where the land is doubtfully fit for agriculture, after a few years of crops the fields are left fallow for a number of years. This is improved on in Sind where after 4 or 5 years of crops instead of fallowing, the fields are put under plantations of *babul* (*Acacia arabica*) called *huris* for some 8 or 10 years before they go back under crops.

Some idea of how a communal forest or shall we say the forest of a collective farm can be run is given by SAHAI, R. (1945). Practical hints on raising forest plantations in the village waste lands in the United Provinces. *Indian Forester* 71 (9) in which he says "Let us consider the requirements of fuel and grazing ground for an average village consisting of 20 families (each family consisting of 5 members and keeping 5 head of cattle). This village will have 100 persons and 100 cattle. (This refers to present conditions but is obviously not an economically ideal ratio of cattle to people for a properly run agricultural community. *Author*). A hundred head of cattle will require a grazing ground of 200 acres. (A very high grazing incidence which most land in the drier districts will not stand. *Author*). One hundred persons will require 500 maunds of wood fuel annually. This quantity of wood fuel can be produced by half an acre of a 20 years old *shisham* (*Dalbergia sissoo*) or *babul* (*Acacia arabica*) plantation. This means that 10 acres of land under *shisham* or *babul* plantation can supply in perpetuity the demand of fuel of the village. Every year half an acre of 20 years old *shisham* or *babul* plantation will be cut down to produce 500 maunds of fuel wood and replanted to produce the same quantity after 20 years and so on. This stage will be reached after 20 years if every year half an acre of waste land is planted with *shisham* or *babul*".

The species suitable will vary according to locality and climate. Afforestation methods in moister areas (say over 30 inches average) are well-known but the drier areas (under 30 inches average) methods and species are not so well-known. The latter question was discussed at the sixth silvicultural conference in 1945 and is being discussed again in the present conference as item 3. A list of species suitable for such areas was published in the *Indian Forester* for February 1946. This list has been revised and enlarged and is being published with explanatory notes on each species as *Indian Forest Bulletin* (*Silviculture*) No. 133 of 1946. There is therefore no need to go into further details on species and methods.

It is however necessary to point out that the most economic species should always be used whether it is for shelter belts, wind breaks, hedges, or farm wood lots and whatever the reason for planting whether for production or for protection. This is particularly so with the species planted for protection purposes and many are the paying minor forest products that can be obtained from species used for such works.

Conclusions

In conclusion in order to emphasise once again the importance of farm forestry, and show how it has been realized in other countries, I give two quotations from America.

I. PRESTON, J. F. (1943). Woodlands in the farm plan. *Farmers' Bull.* No. 1940, U. S. Dept. of Agri.

We know that all land is not suited to, and cannot be used profitably or permanently as cultivated fields, pastures or meadows. Millions of acres of wooded slopes and abandoned fields on farms testify to this truth. Much land unsafe for cultivation can be profitably managed as wood land. Some of this land has to be reforested to get it back into production. Reforestation is expensive and often it will be a long time before the results begin to show in farm income. The effect will be felt much sooner in the increased capital value of the farm. Nevertheless it is necessary to protect and heal such land that has been ruined by misuse or overuse, with a cover that will restore it to productivity. Some land on slopes with erodible soil, cannot be safely or permanently used for other than wood land or wild life crops. If such areas are managed so that they produce a satisfactory income from

the forest there will be no temptation to destroy the cover.

Other sandy, relatively infertile lands are known to be most useful and profitable if devoted to and managed for the production of forest crops. If not now in forest their reforestation is indicated. As previously mentioned farmers in the Great Plains often plant trees on lands of high capability because of their recognised protective value in addition to their usefulness in producing posts and fuel needed on the farm.

To make a profit from wood land the farmer must be willing to train it to produce systematically. He must make up his mind that it is feasible to have woods that will bring in some income instead of having a bush patch good only for rabbits or as third class forage for the cows. Every important structure—like a bridge or a public building or a monument in a park—that has permanent usefulness or beauty is dedicated; so figuratively speaking, because they are to become a permanent useful part of the farm, certain fields can well be dedicated for permanent use as wood land. This is essential because a worthwhile growing stock of trees cannot be developed in a day.

II. ANON, (1938). Forest farming. *Farmers' Bull.* No. 1794, U. S. Dept. of Agric.

(With slight modifications to make it more applicable to Indian conditions).

Forestry Increases Farm Income

BY:

(1) Making waste lands yield a profit by growing timber on:—

Poor soils.	Sandy lands.
Steep slopes.	Unused corners.
Rocky lands.	Eroded lands.

(2) Furnishing paying employment for man and animals in the agricultural off season.

(3) Utilising timber better on the farm and avoiding waste by:—
 Cutting low stumps.
 Using substitute woods in construction.

(4) Increasing crop yields by planting forest tree wind breaks.

(5) Growing more and better timber on the farm through:—
 Protecting the woods from fire, hacking, and overgrazing.
 Selecting for cutting the mature, defective, over crowded and inferior kinds of trees and leaving the straight thrifty and better kinds.
 Planting to fill gaps in the woods.

(6) Marketing the better products direct to consumers at fair prices as:—

Logs	Pulpwood.
Poles	Spokes and felloes.
Posts	Tan barks.
Fuel	Fibres, etc.

MAKE YOUR FARM WOOD LAND PERMANENTLY PROFITABLE.

Conf

A NOTE ON ARAUCARIA CUMINGHAMII, AIT. (HOOP PINE).

By K. L. Lahiri.

(*Silviculture Branch, Forest Research Institute, Dehra Dun*).

SUMMARY:—Hoop pine is a native of the eastern Australian coastal scrub forests. These forests are tropical in character having an annual precipitation of about 60 inches and a mild winter. The pine thrives on almost all types of soil provide the drainage is good and the soil keeps moist all the year round. The pine is a light demander and grows to varying sizes with 2/3rd of its height as clean bole. The percentage of fertility in seeds is low and they do not store for more than a year. Germination percent varies between 20 and 50. Seedlings demand careful handling in transplanting, and in this the "bamboo tube" method has proved successful. Growth is very slow to start with but increases with development of the root system. The wood is used for various purposes and is in much demand. The pine has been successfully introduced in Mauritius and other African colonies. The results of preliminary investigations in India justify further trial for replacing miscellaneous hardwood species in tropical evergreen forests.

Araucaria has about a dozen species and is endemic to the southern hemisphere, occurring in southern America, Australia, New Guinea, New Caledonia, and other islands. The genus took its name from Arauco, a province of Southern Chile, where one of its species occur. Hoop pine, along with *A. bidwilli* is known in trade under the inclusive name of Queensland pine.

Hoop pine grows in company with *A. bidwillii* in coastal scrub (rain) forests of eastern Australia, from the Hastings river, New South Wales to North Queensland. It occasionally extends about 100 miles inland and also grows in the mountain ranges of New Guinea. The rain forest is tropical in character, and consists of dense, closely-spaced vegetation which, sometimes, is difficult to penetrate without the use of a cutting tool. The associates of hoop pine in these forests are *Dysoxylum, Alaeocarpus, Ficus, Eugenia, Cryptocaria, Litsea, Cinamomum* and others.

The average annual precipitation in these forests is about 60 inches but frequently more. The fall is concentrated in the Australian summer months, January to April, other months getting very little rain. The mean annual temperature varies between 70°F and 80°F and that of coldest months is between 49°F and 64°F. Severe frost is practically unknown. In these forests several kinds of rocks upon disintegration yield deep rich soil bearing luxuriant growth. An elevation of 3,000 ft. is the altitudinal limit of the species. Hoop pine favours metamorphic rocks, basalt and granite, and for best development needs a deep, rich, and moist clayey loam. It would, of course, thrive on almost all types of soil, provided the annual rainfall is in the region of 60 inches and the drainage is good. It is known to occur on soft, moist white sand valley of Fraser Island.

Under favourable conditions, the pine grows into a large tree of about 150 ft. or more in height, with a girth of 15 ft. or more. The crown is conical but becomes flat topped in old age. A straight and uniform bole of 100 ft. is not unusual. Unbuttressed, shapely and cylindrical, the bole is 2/3 the size of the tree. It is branded horizontally by a tough elastic integument of coppery hue and lustre. A blaze gives maroon-edged white colour. In good localities the bole is remarkably sound and free from faults. Under natural conditions hoop pine does not grow in pure formations. It grows, generally in mixture with broad-leaved species over a dense underwood. An average stand of dominants has 10 to 20 tree per acre. On stony soil and comparatively dry ridges several hundreds will grow together, primarily due to the elimination of its moisture exacting associates. Growth and form on such soil are not good.

The fruiting season, in Australia, commences in January and continues till April, and the

Occasional ornamental trees have flowered in some parts of India, but the ages of the trees at first flowering are not known. For the firs time one tree in new forest is seen in fruits. The actual time of flowering was missed, but the globular cones became visible in March this year. The plant was obtained from Delhi and transplanted here in 1927. There are about 1,500 full-sized seeds in a pound, but consignments from Queensland frequently contain more. The percentage of fertile seeds varies very much, in different years and is hardly more than 50 in any year. In a cutting test carried at New Forest on seeds received from Queensland 68 out of 100 random samples were defective. Tests carried in Australia showed that seeds stored for 12 months under normal condition were of little value for nursery purposes. Seeds stored at a temperature of 24° in 1936 retained their germinating capacity till 1940. Australia is thus solving her seed supply problem in post-war planting programmes. Further investigations may indicate better methods of seed storage, but for trial as an exotic it is advisable to try for current year's seeds, as we do not know how soon the seeds should be sown after they are brought out of storage. In the past, the difficulty in storing seeds, and the high percentage of sterility have contributed much to check the pine's popularity as an exotic.

Germination per cent varies with the qualities of seed between 20 and 50. Pre-germination treatment by soaking the seeds in water or putting them in a moist bag for 48 hours gives better results. Earlier tests carried out in India gave very poor germination, sometimes as low as 10 per cent. Seeds sown in the end of February at Takadah near Darjeeling gave 52 per cent germination and at New Forest, seeds sown in the beginning of May gave only 20 per cent germination. In these two experiments, among other things incomparable was the different source of supply. Nevertheless it shows the variation in germination per cent and the need for collection of data under Indian conditions. The period of germination varies between 15 to 45 days.

In the first year the seedlings do not grow more than 6 inches in height, so they need protection against rain and splash. Where frost is common and severe, the nursery beds should be shaded. The root system of the seedlings in the first year is very delicate with a long taproot and few fibrous roots, and so

transplanting is not attempted with seedlings less than 2 years old. The difficulties in transplanting, such delicate seedlings have been overcome by raising them in bamboo tubes and subsequently breaking the tubes in the planting pits without disturbing the root system. This method has been successfully tried in Madras. The survival per cent of transplants depends much on the care in handling. In madras one year seedlings transplanted in clearfelled area gave 68 per cent. survival; 90 per cent survival has been achieved in transplanting 18 months old seedlings raised in bamboo tubes.

The seedlings are able to exist for many years under shade and eventually come up to form merchantable timber, but vigorous development requires free access to light as soon as the seedling growth is firmly established. In the first few years the rate of growth is slow but increases as the roots develop. In Australia a height growth of 10 ft. a year has been recorded. Girth growth in natural forests is between ½ to 1 inch per year. At New Forest, the 1931 plantation had in 1945, an average height of 32 ft. and an average breast height diameter of 4.9 inches. In Madras, transplants attained a mean height of 5.5 ft. in four years. In Bengal, in the hills of Darjeeling, an average height of 11 ft. and a maximum height of 19 ft. 6 inches was attained by a 9 year old plantation.

Hoop pine is a strong light demander, so the shade it casts down is not enough to keep down weed growth. Small plants respond well to weeding. Young ones are particularly sensitive to fire, older ones are also damaged by it. They are susceptable to rodent attacks and nurseries should be well looked after. Chlorosis in the nursery has been successfully controlled by application of sulphur and watering with acidulated water. Deer strip the bark of young plants which invariably proves fatal. There are a number of insects and fungi attacking hoop pine at various stages. The seedlings are said to stand only mild frost that is experienced in their natural habitat. Experiments conducted with 1 and 2 year old tubed plants have shown that none was affected by a temperature as low as 23°F. In this experiment the plants were put into freezing chamber for 1½ hours, then kept at room temperature for 2 days and exposed to the sun for 5 days. 50 per cent of the two year old plants were killed at a temperature of 19°F, but small one year old stock survived a temperature of 17°F. In the Darjeeling hills, at an elevation of over 5,000 ft. and with a rainfall of 144 inches, hoop pine has done quite well in a small experimental plantation. The experiments, of course, need repetition before the results can be confirmed.

If a tree is felled and the log is left in the forest for long the wood decays out leaving the bark as a "hoop" or natural pipe. Evenly grown and with only the mildest of growth ring differentiation hoop pine is a firm, strong and fine-textured soft wood. It has considerable toughness but is easy to cut, saw, nail, dress, and polish. Air dry weight is 30-37 lbs. per c.ft. Being non-aromatic and tasteless, it has much demand in the butter-box industry. It has a demand also as pulpwood and is widely used in construction, joinery, etc. Tests in Africa have found the wood to be equal to aspen for match boxes. For match sticks the wood is good but slow to catch fire. If dried in well-ventilated stacks, under cover it seasons quickly without warping, cracking or discolouration. Under favourable conditions, it is usable after six weeks air drying. Wet timber in the rains is liable to develop blue stain.

Hoop pine coppices better than an average conifer, but shoots are not vigorous enough to exert any influence on management. Experiments have found it impossible to develop a leader on branch cuttings of hoop pine.

In Mauritius, the oldest individual is growing from 1880. Successful plantation of hoop pine dates back to 1915. It is at its best in that country when grown at an elevation of 200 ft. to 1,000 ft. with a fairly distributed rainfall of 50-60 inches. The trees start producing fertile seeds at an age of 15 years. The "bamboo tube" method is used to ensure good survival of transplants. In Nyasaland a few trees have shown good growth under river bank conditions with a subsoil moisture during dry season. In Kenya, hoop pine was introduced in 1922 and is showing promise on drier highlands. It is being tried in Ceylon too.

Due to its grand appearance and tropical nature, hoop pine has been known to Indian horticulturists since long. Troup (1921) in his *Silviculture of Indian Trees*, Vol. III, mentioned it as an ornamental tree of little importance in forestry. Foresters only took up its trial recently. During the early thirties, a wave of enthusiasm swept over Bengal.

Madras and New Forest, for hoop pines' trial as a forest tree. In spite of results indicating usefulness for further investigation, the enthusiasm dwindled away as quickly as it started. Practically nothing more than maintaining routine records is done at present. Though the experiments have been mentioned in the body of this article, it would be worthwhile to review them briefly before concluding.

In Bengal, seeds were received from Queensland and were sown broadcast on 26-2-30, on a manured unshaded nursery in the hills near Darjeeling. Germination completed in September 1930 and 50 per cent germination obtained. In the research report of 1930-31, the silviculturist reported the seedlings to be persisting but not growing vigorously, and expressed his doubt whether the species would be a useful exotic in that locality. It was, of course, too early for him to express any opinion at that stage. A small experimental plantation raised in 1933, is growing well at LINGDING with a rainfall of about 150 inches and the elevation between 5,000 and 5,500 ft. In 1942 it had an average height of 11 ft. Conditions in that locality where hoop pine has been tried in Bengal is far from that experienced at its home.

In Madras, the first experiment with direct sowing was conducted in 1929-30, when a few seeds were dibbled at stake in an old clear-felled area, with a rainfall of 60 inches and an elevation of 700 ft. There were only 5 per cent. germinations and so the method was abandoned. Since then a number of small scale experiments have been conducted and hoop pine seedlings have been sucessfully transplanted under various conditions. 50 t ansplants were put in gaps in evergreen forest; practically all of them established and started growing steadily. In September 1931, 45 basketted plants were used along with other tropical evergreen species to replace casualties. In January 1937, hoop pine had 85 per cent survival and an average height of 57 inches. The 15 per cent failure was due to bark stripping by deer which invariably proved fatal. In the evergreen forests at Karianshola, at an elevation of 2,800 ft. and an annual rainfall of 63 inches from both monsoons and no frost, 11 years old plants produced an average height of 15 ft. 6 inches.

At New Forest, on 18-6-31, 160 transplants were put in the experimental garden at a spacing of 10 ft. by 10 ft. The plot was weeded for a few years and when stopped was pulled out by roots and the area sown broadcast with *Crotolaria juncia*, *Cassia tora* and *Indegofera tinctoria*. The plants responded well to weeding. In January 1945, the average height was 32 ft. and average breast height diameter was 4.9 inches (*vide plate* 5).

India is rather poor in soft wood production. Most of our soft wood forests are located in the inner hills, wherefrom extraction is difficult and uneconomic. The extensive tropical evergreen forests are quite rich in timber flora, but very few species there are available in commercial quantity. The questionable durability of such timber under tropical conditions combined with the fact that they would have to stand competition in the market with notable timbers like *sal* and teak restrict their utilization. C. G. Trevor (1928) remarked that both *Araucaria cunnighamii* and *bidwillii* are excellent trees in every respect and suggested that their cultivation in India under tropical evergreen conditions, as in the Bengal foot hills, should be taken up. If we can replace some of our miscellaneous hard wood forests with hoop pine, we would contribute towards balancing our hard and soft wood productions and opening up of new industries in the tropics. The experiments, so far conducted, have not gone beyond stage Ia. Though they did not follow any proper programme or sequence, the results have been encouraging. Further work under a designed scheme is necessary to complete the preliminary research stage. Along with the work it would be worth our while to take up its trial under stage Ib in Bengal foothills, Chittagong, Ghat forests of southern India and other suitable localities.

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Fig. I

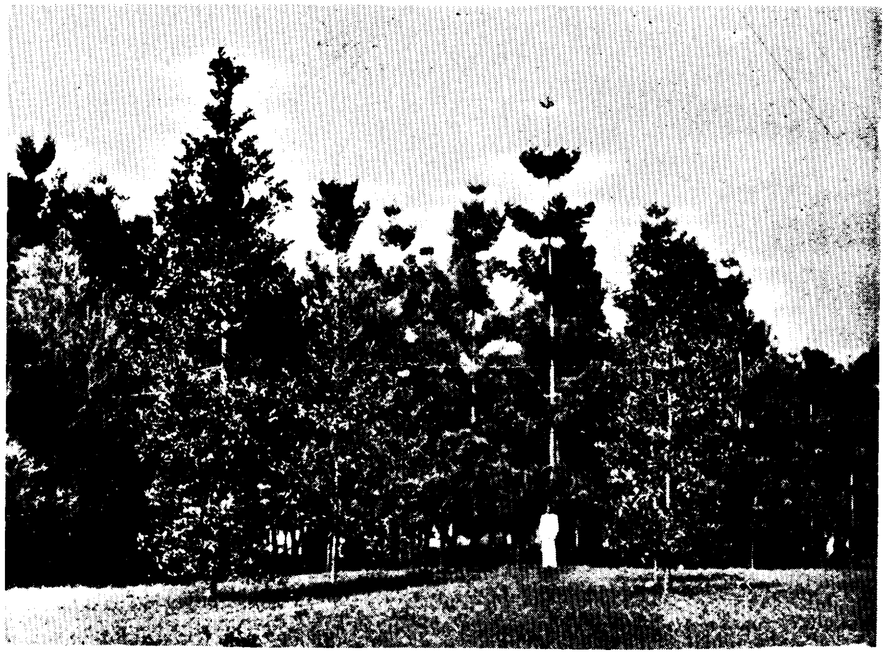

Photo. K. L. Lahiri. 21-11-46.
Araucaria cunninghamii. Plantation of 1931 at New Forest. On the foreground is **Agathis palmerstonii.**

Fig. II

Photo. K. L. Lahiri. 21-11-46.
Araucaria cunninghamii. Plantation of 1931 at New Forest. On the foreground is **A. bidwillii.**

TREE STUMPING ON CHAMUNDI HILL.*

(A new method of establishing tree growth on dry rocky hill slopes)

BY DR. K. KADAMBI.

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History

The Chamundi hill which adjoins the town of Mysore has been the scene of afforestation activity of the forest department for a long time—almost over a quarter of a century. Different methods have been tried to induce tree growth here with varying degrees of success, among them being (1) planting entire in prepared pits of either transplants or basketted plants, (2) planting entire in crowbar holes, (3) sowing in raised beds (small patches 4 feet square with soil worked to a depth of 9 inches to 12 inches and stimulated by a light burn of brushwood) (4) sowing on trench mounds, the trenches being usually 9 to 12 feet long and $1\frac{1}{2}$ by $1\frac{1}{2}$ feet, with the excavated earth *bunded* on the lower slope, the trenches of successive rows made to alternate. In the case of planting, arrangements were invariably made during the earlier days, 1920 to 1940, for watering the plants sometimes at enormous trouble and expense. Protection from trampling by cattle was also provided for by raising rough rubble stone walls about 2 feet thick and 4 feet high all round the planted area to keep out cattle. Miles of such can still be seen standing when one gazes down any slope of the Chamundi hill from a vantage point. These walls did not prove quite as effective as it was at first thoughts, since the cattle soon learnt to hurdle them at vantage points and, once hurdled, the rubble stones slipped down more and more and their effectiveness dwindled to almost nothing. The cattle population in the hill is large and, in addition, the hill forest is resorted to for grazing by the cattle in the populous villages scattered all round the foot of the hill, with the result that the incidence of grazing is fairly heavy. About 500 to 800 cattle resort to the hill for grazing at various seasons of the year, the heaviest grazing being the monsoon period when the forest department will also be at its regeneration work on the hill. Thus, at a time when most grazing protection will be required, very little of it is obtainable. Among other unfavourable factors is the existence of a fairly large human population both on the top and around the hill, who resort to this area for their firewood supply for which admitted or traditional rights seem to exist. These adverse factors combined with the naturally unfavourable climatic and edaphic conditions have rendered afforestation work in the Chamundi hill, a task of no easy execution. (A serious handicap is the total absence of soil. It is a rocky hill where denudation of the tree growth in the past has led to the complete washing away of all soil leaving only outcrops of boulders, rocks and gravel. C. C. F.)

Locality factors

The Chamundi hill which cuts latitude 12⁰—16′ abuts on the beautiful garden city of Mysore whose climate it renders hotter during summer afternoons by the heat it radiates from its bare, rocky slopes. The hill has been well populated from ancient times since it is associated with Goddess Chamund, (the guardian deity of the Royal Family of Mysore), whose temple is situated at its summit and attracts a large number of devotees from the country around. Whatever forest existed in the past has, therefore, disappeared, leaving behind meagre, thorny growth decking the crevices of huge rocky boulders which cover the hill almost uninterruptedly from end to end. The natural vegetation consists of thorny shrubs of *Gymnosporia*, *Carissa*, *Canthium*, stunted *Acacias*, *Erythroxylon monogynum*, *Albizzia lebbek* and rare specimens of *Ailanthus* and some other trees. The commonest shrub is *Dodonea viscosa* along with rare specimens of *Wrightia tinctoria;* patches of *Shorea talura* deck a couple of sheltered slopes or valleys.

Elevation:—The hill rises about 1,000 feet rather abruptly from the surrounding tableland whose generel level is about 2,500 feet high above the sea.

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*Paper presented at the Seventh All-India Silvicultural Conference, Dehra Dun (1946) on item 3—The afforestation of dry and desert areas.

Soil:—The huge boulders are generally of granite with largely sandstone rocks in the upper layers giving on weathering, very poor grey sandy soil through which water sinks with avidity. The main picture of the hill-side from a distance is that formed by the outstanding huge boulders, tree growth being sparse, meagre and almost invisible during the dry weather.

Aspect:—The aspect varies, the main hill ridge lies more or less north-east, south-west and the western slopes have the drier and hotter aspect while the eastern the cooler one. The effect of the aspect on tree growth is not readily visible to the layman's eyes, but closer observation reveals that the eastern side is better clad with the scrubby vegetation.

Rainfall:—This averages 25 inches, the north-east monsoon bringing more copious rain than the south-west. The climate is hot and dry in summer and the temperature varies between about 60F. and 98F.

Afforestation

The methods followed till 1939 for afforestating the hill slopes consisted in planting both transplants and basketted plants, sowing or dibbling seeds in patches or trench mounds and watering the transplants or basketted plants in summer. Owing to the prevailing adverse natural conditions these methods gave slow results and generally met with indifferent success. No marked improvement in tree growth could be noticed from year to year by any of the above methods. Early in 1939 His Highness Sri Krishnaraja Wodeyar, late Maharaja of Mysore, expressed the desire that some rapid way of establishing tree growth which would be visible from a distance and be able to screen off the unsightly rocks from view, would be welcome on the hill. The district forest officers, Sri M. G. Venkata Rao, then thought of the following (novel) method of planting up small trees of various species uprooted from other forest areas, the size of trees varying from 9 to 18 inches in girth and 20 feet to 30 feet in height, after "stumping" them. (There is no "novelty" about this. It is a well-known method and many avenues and parks have been made in this way. It is a question of expense. Mostly softwoods which are noted for propagation by "cuttings". The tree stumps are to 8 feet high. C. C. F.).

The stumps were prepared in the following manner:—

The natural forest trees were uprooted by severing the roots at a length of $1\frac{1}{2}$ ft. from the base of the bole; the stems were then pollarded at a height of 7 ft. from the ground level. The roots were then coated with wet clay and packed with grass and leaves and the cut end of the stem was also smeared with wet clay to prevent it drying up. The tree stumps thus prepared were transported within 24 to 48 hours of uprooting on lorries to the Chamundi hill from Metikuppe and Hunsur areas over a distance of 40 to 50 miles and planted straight away in previously prepared 2 feet cube pits on the hill. The earth was well rammed in so that the stumps were securely fastened to the soil. Immediately after planting one or two potfuls of water (4 to 6 gallons) were poured into the pit. As the planting was done on fairly steep hill slopes, a small mound of gravel about 18 inches high and 4 ft. wide was made on the lower side of the pit and this was supported from being washed down by small rubble stones well packed round it. Thus, any meagre rain water that flows down the hill slope was caught in the pit and retained by the mound. These mounds are locally called "*addakatte*" (Cross *bund*).

The whole operation of uprooting, stumping, transport and planting of the trees was carried out after the first, adequately heavy, pre-monsoon rains at the end of April and early in May. (Early planting enabled the stumps to take full advantage of both the monsoons. C. C. F.).

The method of planting and the entire operation was at first ridiculed by those who saw the bare tree stumps sticking up out of the pits, and it was gently, though in a light hearted manner, mentioned in the highest quarters that this planting would serve to meet the acute scarcity of firewood on the hill.

To the pleasant surprise of one and all, however, several stumps started sprouting in about three weeks and soon put forth their first flush of leaves. (It would be useful to know the percentage of survivals now, if any reliable record of it exists. C. C. F.).

By about October the tree stumps gave straight away moderate sized trees in the afforested area, whose foliage was generally

out of reach of cattle and which required no watering in summer, unlike the planting of small seedlings which had to be watered over the dry season. (In addition most of the species were not suitable for fodder. C. C. F.).

The most important factor in the success of this operation lies in the uprooting and planting of trees with the first heavy showers in April or early May before the trees develop their new flush of leaves in the forest. This was experimentally tested by planting a lorry load of tree stumps, in the manner described above, during July 1940 *after the trees had produced a full flush of new leaves,* which resulted in a failure of 90 per cent of such stumps. Even the few surviving ones were found in very poor condition by October. The period available for planting every year is thus only about a fortnight, towards the latter part of April or the beginning of May, depending upon the first heavy showers. For evergreen species, however, trees planted during August gave fairly good results. (It is not merely a question of the new flush of leaves, but also of making the stumps at home in their new surroundings in time for the first break of the first monsoon. C. C. F.).

The following table gives the statistics of the first year's stumping. Over 40 species were tried, and among them 22 species withstood the shock of stumping well, giving satisfactory results. The best results were obtained in the case of the species *Boswellia serrata, Garuga pinnata, Bombax malabaricum, Proteum caudatum, Cochlospermum gossypium, Chloroxylon swietenia* and *Stereospermum* sp. (*Poinciana* spp. too will be found suitable if they are tried. C. C. F.).

Species	Number of trees stumped in May, 1940	Number with new foliage on 30th June 1940		Remarks
Garuga pinnata	1,232	838	..	
Boswellia serrata	1,153	974	179	All the others are green
Dalbergia lanceolaria	18	4	12	
Pterocarpus marsupium	50	12	38	
Anogeissus latifolia	19	1	..	Are still green
Cochlospermum gossypium	9	9	..	
Grewia tiliafolia	8	7	..	
Albizzia odoratissima	24	3	19	

Three weeks after the above enumeration the planted area was again inspected, and it was found that more stumps of *Pterocarpus marsupium, Wrightia tinctoria, Stereospermum suaveolens* and *Stephegyne parvifolia* had sprouted.

Early in 1941 the trees of 1940 were attacked by a severe plague of defoliators which ate up nearly all the new foliage. It was, however, gratifying to see some time later that in spite of this severe setback all the trees passed through their first summer with scarcely any casualties. (Spraying would have been perhaps useful. C.C.F.).

Mr. S. H. Howard (later Sir Herbert), then Inspector-General of Forests, India, inspected the plantation in December 1940 and expressed surprise at the extraordinary method of planting adopted. He, however, was in great doubt whether the trees would survive their first summer (summer of 1941). Similar views were expressed by the other forest officers of British India and other Indian states who visited the plantation including the Inspector-General of Hyderabad. The operation proved, however, a phenomenal success, with the dry season casualties amounting barely from 5 to 8 per cent.

A much larger area was, therefore, operated upon in 1941 as below:—

Name.	*Area planted up.*	*Number of tree. stumps.*
Race View block.	66 acres.	6,500
Anjaneya block.	40 acres.	3,500
		10,000

The work was started by the middle of April and completed in about 25 days. The trees planted within the first fortnight started producing new leaves in about a month, but

those planted later took almost double this time. The survivals exceeded 90 per cent. (The necessity for really early planting is indicated by these results. C. C. F.).

In 1942, again, similar work was commenced on the 9th of April and completed by the 6th of May. About 70 acres were planted up with 5,000 trees in Jwalamukhi and Lalithadri blocks. The survivals exceeded 90 per cent.

The doubts expressed by the Inspector General of Forests (Mr. Howard) and other forest officers were found to be groundless as could be seen by the phenomenal success of the operations of 1940 and 1941 in the Race View and Anjaney blocks.

In spite of its success this method was given up from 1943 under the chief conservator's instructions, owing, to the *high cost involved.* Each tree stump cost, on an average, nine to twelve annas to uproot, transport and plant up. Judging from the results achieved by this method and in this unfavourable soil and climate, the cost cannot be considered excessive, but it is certainly very high compared with that incurred in the formation of teak and other plantations.

During this year (1946) the method was again revived by the author in Mysore district on small scale and 352 tree stumps were planted in the bird sanctuary at Ranganthittu, an island formed by the river Cauvery about 9 miles north of Mysore City. The tree stumps were got from Veeranhosally forest about 45 miles from Mysore by lorry and planted late in May 1946. (April planting would have been better. C. C. F.).

The species planted are *Cochlospermum gossypium, Garuga pinnata, Boswellia serrata* and *Bombax malabaricum*. About 60 per cent of the stumps sprouted within three weeks *i.e.* by the 20th of June, but further observations have not been possible as the river Cauvery is in flood and there is no access to the bird sanctuary for the time being, till the floods subside.

Conclusions

'Tree Stumping' is a new and novel method of afforesting bare hill slopes and other dry places and of securing straight away a forest consisting cf trees of moderate size whose foliage is out of reach of cattle. It has several other advantages, among them being that, the method, if practised correctly and with species of known suitability, guarantees success, and we get a low forest within a couple of months in a place where nothing existed before. Unlike seedlings which take years to grow to respectable sizes and may have to be watered over the summer for some years to be kept alive—a costly and laborious process, tree stumps need no watering or looking after from the very start. The high cost of watering is thus eliminated and, in the long run, the method turns out to be really cheaper than planting seedlings. One great disadvantage of the method, however, is that, its practice is restricted to a *few suitable* species only, unlike the planting of seedlings which is possible with any species. (The species are mostly of no economic value. C. C. F.).

Another disadvantage, as against planting seedlings, is the high initial cost of formation of a plantation. Including the putting up of cross *bunds*, stumping may cost as much as nine to twelve annas or more per tree.

It is a method which requires closer study and which, in the writer's opinion, deserves wider advertisement. (Its use has to be restricted to cases where quick results are desired. C. C. F.).

PROPAGANDA IN FORESTRY

By T. Jeyadev, B.Sc. (Hons), A.I.F.C. (Hons).

(Assistant Conservator of Forests, Nilambur)

Introduction

Propaganda is admittedly an ugly word. The word carries with it an odium, since it implies more often than not self-praise, vanity, boasting, egotism, exaggeration and what not. But what is there in naming a word so long as the word indicates a genuine attempt to educate public opinion and foster the "forest-sense" which for various reasons, is so lamentably lacking in this country? There is no knowing what useful ends it will lead to, if only it is carried on honest-to-goodness lines. It is by its artful aid that man has reaped some of his greatest benefits. Propaganda, it is said, is the other side's case put so convincingly that it annoys you. But instructive propaganda will annoy neither side and elicit whole-hearted co-operation from the public.

I propose to consider its imperative need in Indian forestry for achieving more efficient management of our forest resources. That is possible only with the willing co-operation of the people for whose benefit forests are being administered by the forest department.

Class of forests for which propaganda is essential

As early as in 1894, the general policy of the Government of India in relation to forests was laid down by classifying the forest areas under their control into four classes.

Calss I:—Forests, the preservation of which is essential on climatic and physical grounds—the so-called protection forests.

Class II:—Forests which afford a supply of timber for commercial purposes—this includes plantations.

Class III:—Minor forests of inferior type, managed for the production of wood and other produce for local consumption and grazing. These forests are of great importance in agricultural districts.

Class IV:—Pasture Lands:—Classes III and IV contain the areas which are mainly, if not entirely, for the production of forest produce necessary for the requirements of the local population. It is in such forests, where the work of the department is intimately connected with the daily life of the people, that the willing co-operation and full understanding of the need for the conservation of forests are necessary between the public and the forest department. This article chiefly refers to these classes of forests, where proper education of the public regarding forest matters is absolutely necessary for the efficient and useful management of these forests for the benefit of the public.

Propaganda essential to foster "forest sense" and help forest conservancy

Though years of organisation of forestry in India have resulted in the development of our forests to a stage of which any forester in our country can feel justifiably proud, it has to be conceded that the "forest sense" in people is far from developed. I have heard many talk glibly of the immense forest wealth of the nation. But any student of forestry knows, that the proportion of real forests in India is far from the desired percentage that is necessary for any progressive civilized state. The post-war reorganisation of the country rightly includes plans for increasing the lands under forest department—mainly village forests. Anyone who has seen the miserable scrub that constitutes the minor forests of the country will agree that there are more hairs on a bald man's head than there are healthy trees in such forests. Our scrub jungles in inhospitable tracts are evidence of desperate vegetable tenacity, struggling for life tenaciously in spite of goats, camels and man. Admittedly it is the duty of the state to extend the village forests for providing greater amenities to the villagers. And at the same time it is reasonable to entertain doubts whether the effect will be a consummation of the art devoutly to be wished, since no useful purpose will be achieved unless the people of the land appreciate the necessity. If more land is to come under forests and the people continue to be ignorant of the usefulness, the necessity and the importance of the forests, such extension will be no more than an additional burden on the forest department, who are already burdened with the

responsibility of conserving the forests against great odds. Before increasing the forest areas it is absolutely necessary that the public should be made aware of the benefits that would accrue to them and that for their continued enjoyment of the benefits their willing co-operation is essential.

Ignorance of the Public regarding forest matters

I really wonder how many besides students of forestry and foresters know the direct and indirect benefits of the forests. Does the man in the street in India know anything about them ? Many a district forest officer in the inhospitable tracts, where there is a keen demand for forest produce but where Nature is not so bounteous as elsewhere, would have a bad headache in the conservation of such forests. They would bitterly complain about the lack of co-operation of the villagers and a general hostile attitude. But if one analyses the requisites of willing co-operation and friendliness towards the forest department it would be apparent that before the villagers can co-operate they should know in what they are to co-operate, why they have to do it and how they can do it. The Indian villager is often illiterate, orthodox in his convictions even in other matters. Regarding the necessity of conserving forests his knowledge can be taken as absolutely nil. Why blame the poor illiterate villager? How many among the so-called educated know the usefulness of forests? I can tell you that half the world thinks that a forest officer is a *Shikari* holidaying in the woods who just cuts and sells what Nature has made—the immense forest wealth! And the other half of the world knows nothing about him. In these circumstances it is no wonder people lack "forest sense" and do not have a respect for the forest property. And the last thing one can expect is willing co-operation in a matter they do not have the least idea of. Small wonder then, that no part of forest administration has created so much ill-feeling and misunderstanding as forest protection. If forest protection by the state is for the benefit of the public, why then do people dislike it? Because, they do not know anything about the good done to them. There is no use of the forest department playing the good Samaritan, unless the recipient is willing to appreciate the good turn done to him and willingly co-operates for the betterment of all. No organisation can be worked sucessfully or attain its fulness without harmony and mutual co-operation of the parties concerned in it. And such co-operation will not be available unless the people know that it is in their own interests. And if they do not know it, it is the duty of the state to make it known to them with the help of useful and judicious propaganda so that both the state and the people can get the best out of it.

Interdependence of Agriculture and Forestry

Propaganda regarding forestry is nowhere more needed than in an agricultural country like India. The interdependence between agriculture and forestry is well known but the agriculturists or the country know sweet nothing about it. In this connection I feel a strong temptation to quote Prof. Troup in his *Work of the Forest Department in India*. He says, "The work of the Forest Department should not be judged from the revenue producing point of view. This side of its activities is unquestionably of immense importance but the first duty of the department is to provide the wants of the agricultural population and to maintain the areas commited to its charge in such a condition that their indirect benefits shall be as beneficial as possible. Forestry has been termed as handmaid of agriculture and nowhere does this apply with greater force than in India which is essentially an agricultural country. Apart from their ordinary domestic and agricultural requirements of timber, fuel, thatching and fodder grass, grazing and numerous other minor products, in many parts of the country, the people are largely dependent on the forest for their very existence". Propaganda among the agriculturists regarding this interdependence between agriculture and forestry and the position of man in the triangle of agriculture—forestry—man, should help to teach the agriculturists not to slay the goose that lays golden eggs!

Benefits of organised Propaganda work

Propaganda thus will aim at creating the necessary "forest sense" among the public and improving the efficient working of our forest lands. It will educate the illiterate villager so that he may respect forest property and derive only the benefits of interest from it without laying hands on the capital. It

will dispel the wrong idea that forests are no man's lands and teach him that the injuries inflicted on it though small and seemingly harmless will affect his posterity. Even in cases where wasteful rights prevail it will help the forest department to come to a gentleman's agreement with the villager so that the right may be exercised with due regard to maintenance of the forest property. Propaganda will bring home to the people the modern advances in soil conservation, rotational grazing and improvement of pasture and other such work where the willing co-operation of the people is necessary. Propaganda will explain to the layman how his interests, are those of the state by disseminating correct ideas about forest conservation and dispelling popular misapprehension. Once the villager knows all about the forest and its relation to him, he will be sympathetic in his attitude towards forest department and that will surely relieve the headache of many a forest officer who at present is carrying on the administration of minor forests. Further the education of the public about forests will make forestry a pleasure, for it will be possible for the forest officer to work with the people and for the people who understand the purpose behind it. Propaganda, apart from eliciting the willing co-operation, will bring many a good return along with it. The propagandist will encounter during the course of his activities, people setting forth their grievances and that will help to modify the forest work and to remove discontent with due regard to forest conservancy. Propaganda will be an impetus to research for new methods of tackling the problem, a means to acquire more knowledge about other provinces and countries, for it is in the nature of the propagandist to find out the best to treat the public with. Very soon he will find that his material is exhausted and he will be out to modify for the better, the nature of the work as it is carried on now. That will result in the improvement of methods hereto practised by the department. Propaganda is like a ball that gathers momentum once it is set rolling and certainly gathers no moss.

Some suggestions regarding the planning of Propaganda Work in Forestry

Having set forth the endless good that would result in educating the public with a view to stimulate in them the general interest in forests, I would like to point out the ways of doing it. It has to be admitted that the forest staff as it is at present constituted cannot mix too freely with the public and so it is necessary that a special branch should be created to do propaganda work. I would propose that a propaganda section be attached to the working plan circle or to the silviculturists division or function independently in every province. The section will be under the general supervision of the chief conservator of forests. The propaganda section will be under the direct control of the forest propaganda officer—or, if you don't like the name, forest publicity officer. He will be assisted by a number of range officers etc., according to the extent of the province and the magnitude of work undertaken, each ranger and his publicity staff being in direct charge of a particular area. The main duty of the forest publicity officer will be to arrange meetings in villages, towns and cities and educate them about the usefulness of forests, and their relation to them. The men chosen for such activities should be persons who have an aptitude for such work and those who have the capacity to mix freely with people. The Indian villager is often illiterate and the propaganda done in villages should be simple and direct while in towns and cities they can be educated on different lines. Writing articles of popular interest about forestry in magazines—both in English and Indian languages of the province—will stimulate interest in the literate public. But the aim of the publicity officer should be to contact the villagers who are in the vicinity of forests and arrange periodical meetings. Posters illustrating forest topics should be exhibited in all public places. Arrangements will be made by the publicity officer to have regular village programmes to be broadcast by the help of the different A. I. R. stations in different languages. Since the Indian villager is illiterate, education regarding forest matters should be done through the medium of posters containing effective pictures. If possible the village meetings should include the exhibition of cine-films—even the small cine-kodak will do. In schools and colleges periodical meetings and exhibition of films should be arranged. Half-yearly or annual exhibitions should be arranged in each territorial circle, the venue of exhibition each time to be in different places in the same circle.

There should be an All-India publicity officer

under the guidance of the F. R. I. and under the direct control of the Inspector-General of Forests to co-ordinate the efforts of different provinces and to arrange on a large scale certain activities of the propaganda work. For example arrangements to have short news-reels taken to be shown in cinema houses etc. may be done by the All-India publicity officer. Works done on a big scale in different places like Bijapur, Hoshiarpur or even outside the country should be exhibited to the public. when propaganda work is carried on an All-India basis, it will be helpful even to the professional foresters to learn about the different kinds of work done elsewhere and this will go a long way to reorganise their work in the light of fresh knowledge.

Conclusion

I am confident, that useful and judicious propaganda done on these lines will be helpful to obtain the willing co-operation of the public in forest matters so that the forest department which exists to cater to the need of the public can carry its burden in the real interests of the people and show a sustained benefit to the people. Propaganda will create public opinion in forest villages which in time will have a great moral force aganist forest offences. No organisation can be worked successfully or attain its fullness without harmony and mutual co-operation between the parties concerned in it. And I am sure propaganda on forest matters will elicit such co-operation for the betterment of our forests which are our national asset and on which the country is dependent for its very existence. Indian forestry as it stands today needs its aid!

EDITORIAL NOTES, COMMENTS AND MISCELLANEA

Durability of timber.—Under favourable conditions there is nothing in the world of living things which has a greater endurance than wood, according to an item in the *Timber Trades Journal* of September 21, 1946, quoting from the *British Columbia Lumberman.*

In many parts of Great Britain buildings having a framework of timber which have stood for several centuries, though not so frequently met with as formerly, are even today a not uncommon sight. In North America there are buildings which date from the beginning of the colonial history.

To find the best examples, however, of the longevity of wood structures, the item point out, one must go to countries with a longer history. There are sacred temples in Japan built of wood 1,300 years ago. The well-preserved wooden articles found in the tomb of King Tut date back at least 3,500 years.

Cypress stumps have been excavated in the United States whose age is not less than 20,000 years, and may be many times that figure. In 1920, while digging a tunnel, a piece of wood was exhumed from 500 ft. underground which was identified by the Forest Products Laboratory at Madison, Wisconsin, as belonging to the Sequoia family. This was buried in gravels of a tertiary stream bed about 12 ft. under the lava cap of the great flow which terminated the tertiary period. The wood, therefore, was at least one million years old and was remarkable for its state of preservation. Except as to the lighter spring wood or sapwood on the outside of the log, it had not materially deteriorated.

* * * *

Soil Conservation.—Dr. Hugh H. Bennett, Chief of the Soil Conservation Service, U. S. A., expressing his views on soil conservation says:

"Soil conservation is not a passive science, something that is to be applied only when there are signs of danger. For then it is too late. Soil conservation must be an ever watchful sentry responsible for the safety of the source of food production for the world, now and for all times.

Soil conservation becomes the basic link between nations for the betterment of people as a whole. It is a constructive force for binding together land users within community areas, and for building international goodwill and understanding. It will lead in the direction of world peace probably more than any other activity of mankind. We might very well recall this, then, when we come to reflect upon the fact that now, 1943 years after the birth of Christ, we have on our hands the most terrible of all the long history of wars. Something has failed somewhere. It may be that our costly failures across the

EXTRACTS

ERADICATION OF PRICKLY-PEAR.

George Mulgrue

No one really knows who first brought the prickly-pear to Australia. There is a story that Governor Arthur Phillip did it to provide food for the cochineal insect, so that he could have dye for his soldiers' coats. But that probably is not true. What is much more likely is that some one thought that cactus plants would be nice as ornaments in the graden.

The menace

There came a time when it seemed that the plant would take over the whole country. It was not the originally imported plants that did the damage. No one heard much of the prickly-pear till farmers began about 1860 to use it for hedges and as cattle food. By 1900 it was becoming a real menace. People began to realize that something must be done. The only trouble was that no one knew what. To attack the pest with mechanical and chemical methods would cost about Rs. 85 an acre, and as the land was only valued at between Rs. 2-12 and Rs. 16 an acre, this was obviously uneconomic. A search began for some other way to fight the pest.

In the meantime, the prickly-pear was really getting under way, and by 1925 had taken over an area of 1,000 miles long in Queensland and New South Wales, almost as far south as Sydney. The pear occupied an area of more than 60,000,000 acres, which included some of the best country—a belt that began about 50 miles from the coast and extended up to 300 miles inland. The rainfall of these parts was from 20 to 30 in. and it contained land suitable for sheep and cattle grazing, dairying, and the growing of maize, wheat and cotton. Some of

this country was as yet unoccupied, but much of it had already been settled and the settlers were fighting a losing battle against the invasion. They tried ploughing the pest, crushing it and a hundred other things, but they were mostly hampered in these mechanical methods by the heavily timbered nature of great deal of the country. In the end, poisoning, usually with arsenic in some form, was found to be the only method possible, but this too was far too expensive, and gradually more and more of them gave up the struggle and abandoned their farms.

There seemed to be no remedy, and in 1924 the Queensland Prickly-Pear Commission announced that the task of clearing was impossible and that even if it were not, the cost for the first clearing alone would be in the neighbourhood of Rs. 85,60,00,000.

Possibilities for biological control

But the scientists were not satisfied. Back in 1912, an almost forgotton commission had reported that there was a future for biological control of the pest; that there were insects that could hold down cactus growth. In 1920 scientists had persuaded the Governments of the two prickly-pear infested States, Queensland and New South Wales, and the Commonwealth Government, to co-operate and form a Prickly-Pear Board, which was to work on the findings of the earlier commission.

Entomologists were sent to America early in 1920, and while the Queensland Prickly-Pear Board was making its gloomy announcements, they were working quietly at a field station they had set up in the United States. There were several little insects that were known to be enemies of the pear, but the scientists' problem was bigger than that. Before they could import any of them into the country, they must be sure of several things. The chief of these was, would the insects when imported into Australia, turn on other forms of vegetation? Would they destroy the prickly-pear, only as a prelude to destroying valuable food crops ? The scientists had to be sure of these answers, because so much of Australia's production comes from the land.

Cactus-killing parasite

The patient work went on and before long the scientists found that while there were several parasites that tended to destroy the prickly-pear, one of them was sudden death to it. This was the Moth Borer known as *Cactoblastis cactorum*, and it came from Argentina. They began to concentrate upon it. They studied its life history and its effect on various hosts. It was found that it could live on the cactus plant and on the cactus plant alone. They found, in fact, that this was the result with almost all of the cactus-attacking parasites. It seems that the cactus family has its own definite insect fauna. Very few of these will live on any other form of foliage, just as very few insects that live on other plant can survive on the cactus.

Import of Moth Borer

Having established the fact that the *Cactoblastis* would not be a danger to any other plants in the country, scientists felt it would be safe to introduce it into Australia. The field stations in America and the Argentina collected selected insects and their eggs and brought them to Australia. The first batch of eggs arrived in Australia in the larvae stage in 1925. During the next spring, the larvae turned to moths, which laid 100,650 eggs. They were kept in rearing cages, and the next generation numbered 2,540,000 eggs. There was a 900-fold increase in 12 months, for two generations of *Cactoblastis* are born every year.

Mass distribution of eggs

The first experimental liberation went on until the end of 1927. By then 9,000,000 eggs had been distributed in lots of from 100,000 to 250,000 all over the affected country. It was not long before it became obvious that rearing in cages was unnecessary. The insects increased so much in places where they had been liberated, that it was only necessary to collect the eggs from nearby plants and spread them in other places. Mass distribution began in 1928, and went on until 1930, by which time roughly 3,000 million eggs had been distributed.

The method was simple. The little sticks of eggs were lightly glued to squares of paper or placed in waxed paper quills, and the squares or quills were pinned to the cactus plants. The insects multiplied so rapidly that big gangs of men equipped with trucks had to be employed to spread the eggs far and wide. Within six years of its importation, *Cactoblastis* was firmly established from one end of the pear belt to the other.

Amazing results

The result was successful beyond all expectation. By the end of 1928, each liberation area showed about 1,500 acres of ground cleared of cactus, and by 1932, vast tracks of pricly-pears had been reduced to pulp, in a most spectacular manner. In fact in August of that year, 90 per cent of the pear had disappeared.

Battle not over

But even then the battle was not over. For by killing off the cactus, the little *Cactoblastis* was virtually committing 'suicide'. It could live only on cactus, and that was nearly all gone. The *Cactoblastis* began to die off in a most alarming way, and in the meantime the cactus was growing again. The seeds from the rotted plants had fallen to the ground, and because there was no *Cactoblastis* to control them, they began to expand just as they had done in the years gone by.

However, the *Cactoblastis* had not died out completely, and very soon it was flourishing again. By the end of 1934, all the area of regrowth was under control again, and now although there are times when the cactus seems to be getting under way once more, there is no cause for alarm. For whenever the cactus starts growing the *Cactoblastis* starts too.

—*The Journal of Scientific and Industrial Research*, Australia, January, 1946.

HORMONES AND TREES

By W. E. McQuilkin,

Northeastern Forest Experiment Station, Junior member, S.A.F.

In this day of splitting the atom, bouncing radar beams off the moon, the medical wonders of sulfa drugs and penicillin, and the insecticidal marvels of DDT, poor bewildered John Citizen is conditioned to believe almost anything.

Among the revelations of modern science, discovery of the roles of vitamins and hormones in the healthful functioning of both plants and animals has aroused widespread public interest. The past decade has witnessed much valuable research with these substances, both in basic knowledge concerning them and in their practical applications. Referring to plants alone we can, for instance, now grow root cuttings that formerly refused to root, we can make apples hang on trees after they normally would fall, we can treat tomato blossoms and produce seedless fruit without benefit of pollen, and we can kill weeds in the lawn by a peculiar disruption of their physiological processes, while leaving the bluegrass unharmed. To the lay public, such discoveries as these were fascinating; to the writer of popular articles on plant science, here was a field to be exploited.

When scientific work is reported by professional writers the truth, however strange, sometimes is not good enough. All too often results are embellished and exaggerated, usually to the profound embarrassment and disgust of the researcher furnishing the basic information. However, such ethics on the part of the writer are something of which most readers remain unaware, or only half suspect. They have no ready way of knowing. Hence, they are wholly or partly convinced, frequently with the aid of glowingly captioned pictures, that the printed word is true. In some instances, either incidentally or by deliberate collusion, such stories serve as highly effective advertising for some new product which certain vendors rush to provide at perhaps 1000 per cent or more mark-up over costs of production.

For a horrible example of such unrestrained sensationalism, an article which appeared in 1939, relating to Vitamin B_1 still stands almost without a peer. You don't need to read it—just read the title to sense the enthusiasm of the author for his craft. Here it is: "News of an exciting discovery—of five-inch rose buds, daffodils bigger than a salad plate, snapdragons six feet tall, roses transplanted while flowering—the story of a miracle-working powder and how to use it in indoor and outdoor gardening this fall."[1] How many people, as a result of this article, paid $1 for a little vial of B_1 powder that probably could have been marketed at a profit for 5 or 10 cents—and their flowers grew no better than before! There have been other

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[1]Better Homes and Gardens 18 (2): 13, 94-96.

articles in similar vein, dealing with both B_1 and the hormones, though few have displayed such flagrant disregard for reality.

That such publicity is swallowed by more than a few gullible gardeners was demonstrated early in the war when interest in camouflage planting was at its peak. With several other foresters and plant scientists, the writer was associated in tree transplanting experiment undertaken at the request of the Camouflage Branch, Army Engineer Board. Contacts were mostly with civilian landscape architects employed by the Army. These gentlemen were pretty thoroughly convinced that the labor and care required for successful tree moving could be greatly reduced and simplified by use of vitamins, hormones, or some similar treatment. They were not a little disappointed, and perhaps a bit skeptical of our professional competence, when we were unable to deliver a technique fulfilling their preconceived expectations.

These remarks are prompted at this time by an article entitled "Detroit takes the Farm Road"[1] appearing in a recent number of a popular farm magazine. It purports to tell of a movement among Detroit industrialists to promote farm prosperity through various research projects. Though hormones are not here the main theme, they are extravagantly mentioned in connection with one project in which C .F. Kettering, head of the Research Division of General Motors, is said to be searching for a commercially feasible way to make trees grow faster. This reference to hormones is of special concern to foresters for three reasons: (1) it pertains to forest trees, not landscaping and gardening material as have most previous stories of the sort; (2) the periodical carrying the story is one which reaches the type of farmer most likely to be interested in forestry; and (3) its association with the name and integrity of Mr. Kettering confers a degree of credibility that otherwise would not obtain. The alleged achievements in accelerating tree growth very likely will result in many requests to foresters for further information.

The statement that makes one's eyes bug out is the following appearing on page 59 : "The old master of motor research says he can already make them [trees] grow three or four times as *fast as normal*, experimentally, by feeding them auxins—sometimes described as plant hormones —and the only problem is to get the process on a financially practical basis."

To the present writer, this smelled like the same old brand of sensationalism as had appeared in various forms before. However, because of the reference to forestry the facts behind the statement, if any existed, seemed worth examination. Accordingly, letters asking for further details were addressed both to the author of the article and to General Motors. The author's reply referred vaguely to such a statement having been made and discussed repeatedly, as if it were well known, by the promoters of the Detroit program. He admitted that he had not interviewed Mr. Kettering, nor checked the facts further. From General Motors came a reply, initialed by Kettering himself, the significant part of wich reads as follows : " . . . someone must have his wires crossed, as I never made such a statement. What I perhaps did say was that there was a difference of three or four times in the rate at which various types of trees can produce cellulose." With this latter remark, of course, no one would disagree.

Thus, the above-quoted statement from the article which, if true, would be a discovery of far-reaching significance to forestry, proves to be just another instance of either garbled or deliberately sensational, irresponsible reporting. Perhaps few foresters will have read the article; certainly few would have accepted the statement on hormones and tree growth without reservations. This expose is not presented to save foresters themselves from being taken in. Its purpose is to provide them with the background and facts required to refute authoritatively, in their contacts with the public, any credence they may find being given to the falsely attributed Kettering statement. They can assert unequivocally that, by Kettering's own word, the report is not true.

—*Journal of Forestry*, Vol. 44, No. 7, July, 1946.

[1]Country Gentleman 116 (2): 15, 58-60 (February, 1946).

THE FUNCTIONS OF THE FOREST

By. G. E. Godwin.

Is a mixed country property a biological entity? Lord Glentanar's article in Vol. 59 of the Journal was stimulating in its stressing of a point of view sometimes neglected; at the same time disagreement might be expressed on two of the points brought out—the primary function of the forest, and the use of mixtures as against pure conifer crops in first rotation afforestation of hill land.

The primary function of the forest must depend on the point of view—nature's or man's. Forest, in nature's scheme, is a climax type of vegetation, best adapted in the particular circumstances of climate and environment to occupy the ground and to survive. Nature clothed this island with a variety of forests before man was numerous enough to interfere. Utilisation of the forest, or indeed of any other feature, for the benefit of man was no part of nature's intention. But to man the primary function of everything on earth is to serve his own well-being and best interests: the primary function of the forest is to be of use to him—by providing wood, fuel, or other produce, or indirectly by providing shelter, or preventing erosion, or, at the end of the scale, to give way to agriculture. This was not nature's idea. Nature's idea for the utilisation of this island is to revert to forest and marsh, and man must resist this purpose if he is to survive. What forest man decides to leave or to establish is for his own use, and must be made to serve his own ends.

If man uses the forest thoughtlessly he may get erosion, floods, wind, devastation, drought, and sandstorms, but this is due to his imperfect understanding of where his best interests lie, and not to his departing from nature's intention. He may even improve on nature for his own ends by planting forests on the coastal sands where nature planted marram grass, or on reservoir catchment areas to improve on nature's bog and willow scrub. He will reintroduce larch and spruce to this island, though nature banished them a very long time ago; he may plant beech in parts of Scotland and Wales where they are not found in nature. He will not stick to nature's ideal forest of oak and hazel and alder and birch. Admittedly his forests will perish if not tended, and nature will reimpose her own, but he will fight nature as long as he intends to survive.

A mixed country property is surely an *economic* entity; nature's biologically balanced utilisation of the same area would be something very different.

To come to the use of species in afforestation, the function both of private and state forestry is presumably to combine timber production with any other desirable aim—land utilisation, prevention of erosion or blown sand, shelter, amenity, sport, rural employment—and not to restore nature's climax vegetation. Hence the forester will plant those species best designed to achieve the aims he has in view, and will not ask himself what nature would do in the circumstances. Nature would probably start off with thorns and birch and mountain ash and hazel, and aim at an oakwood at the end of it all. The forester wants timber and other things, so he plants Douglas fir, which gives him timber and achieves his other aims—or he would have chosen something else. The primary aim when afforesting a hillside is usually to produce timber and to go on doing so, and the writer would hold that this is usually best achieved on typical poor, acid hill ground by planting pure conifers in the first rotation. Evidence suggests that this is quite feasible, and normally satisfactory. A hill farmer ploughs his land and sows oats, and cannot be criticised for doing so on the grounds that he cannot go on growing oats for ever, or even for four years running. His crop of oats turns out to be satisfactory, and by judicious rotation he and his descendants produce crops on his field for ever. Continental evidence does not really conflict with this; mixed woods are usually favoured after many rotations of pure conifers on the same site.

A pure crop is easier and cheaper to plant, and in the first rotation often produces a better wood. We have all seen conifer woods with gaps and coarse trees due to failed hardwoods; this may be due to neglect, but may be due to the hardwoods simply not growing in

relation to the rest of the plantation. A gappy plantation results, and down goes the yield. Another common sight on poor ground is a thriving conifer plantation bordered by a belt of miserable hardwoods, which will provide neither shelter nor fire protection; the beltmight have been established better by underplanting towards the end of the first rotation, and fire protection secured by wide, unplanted, and perhaps cultivated strips. The chief danger to forests in this country is usually a ground fire rather than a crown fire.

There is some doubt as to whether the mixed and uneven-aged forest has become the proved and established policy on the Continent. There has certainy been a swing away from large even-aged forests, but there is some evidence that the selection forest vogue is receding. At any rate, the interpretation of the term "mixed and uneven-aged forest" is often a forest containing stands of many age-classes of both conifers and hardwoods, rather than a forest containing stands of mixed hardwoods and conifers of uneven age. In the manner of the farmer sowing oats, the forester may plant pure conifer, and later on he will take steps to ensure that he can go on growing forest on the ground for his own ends.

—*The Scottish Forestry Journal,* August 1946.

WEED INCIDENCE IN MANURED LAND

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Biochemist

and

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It is a common experience of farmers that fields manured with cattle-dung manure are very weedy and need a closer attention in cleaning and inter-culture. This greater weed incidence in manured fields is found to be due to the presence of extraneous weed-seeds in the manure itself, which get dispersed in the land and grow vigorously because of the ample plant food. Is it possible to destroy weed seeds effectively during the preparation of manures and thereby mitigate the weed-problem? Our experience in composting town-refuse is encouraging in this direction.

Destruction of weed-seeds by composting

The main bulk of town-refuse compost is made up of *katchra* which comes from such varied sources that it is not surprising to find an unusually large number of weed-seeds in it. In the preparation of compost, night-soil is applied to a layer of *katchra* spread in a trench, *in the proportion of* 1 : 1 *by weight. About* five to six layers of *katchra* and night-soil are thus filled in one trench and the refuse processed in this manner is left undisturbed for a period of about six months by which time it is converted into a well-decomposed mass of manure. Within three to four days of the processing, described in brief above, a large amount of heat is generated and temperatures above 55°C. are usually attained. The high temperature level in the decomposing refuse continues for over two months and gradually the temperature falls down to about 45°C. by the time the manure is ready for sale. It is found that this intense heat developing in the manure effectively destroys almost all weed-seeds originally present in the refuse.

Trials with different manures

The above fact has been attested experimentally. In a trial conducted in pots with four replications, the following manures were applied at the rate of eight tons per acre: (1) Town-refuse compost, (2) Cattle-dung (farm-yard) manure and (3) Poudrette manure (*night-soil trenched without the addition of katchra*). (4) A control, without any application of manure, was also run. No crop was grown in the pots, but the weeds emerging

were uprooted and a count of the weeds removed from each pot was recorded. The experiment was continued till no more weeds grew. The number of weeds in each treatment in an area of 7.1 sq. ft. was as follows:

1.	Town-refuse compost	34
2.	Cattle-dung manure	53
3.	Poudrette (night-soil manure)	70
4.	Control	39
	Critical difference for significance ($P=0.01$)	14

Results of the trial

The above results are of considerable practical importance. It is observed that town-refuse compost treatment does not show a larger number of weeds as compared to the control showing thereby that its application does not add any extra weeds to the soil. On the other hand, a large increase of weeds is observed as a result of the application of the other two manures, the incidence being nearly one and a half to two times that in the case of the control. This shows that cattle-dung manure and poudrette both contained weed-seeds which retained their viability throughout the course of decomposition.

High temperatures destroy weed-seeds

It is interesting to note in this connection that during the preparation of cattle-dung manure or poudrette the heat generated as a result of rotting is not very high. Carbonaceous fractions which can develop considerable heat on decomposition are not contained in animal or human excreta, as they are absorbed in the process of digestion by the animal system and used for production of body heat. Hence during the rotting of cattle-dung or night-soil alone, the temperature does not go beyond 50°C, and this temperature level is not high enough to destroy weed-seeds. On the other hand, town *katchra* is rich in the carbonaceous substances which generate considerable heat on decomposition which serves to destroy weed-seeds.

It is possible to exploit the principle of heat development in rendering cattle-dung or farm manure free from weed-seeds. If fairly large quantities of litter waste from the feeding bier and other suitable crop wastes, are mixed with dung and then the material is put into manure pits and properly composted, it will be possible to generate enough heat to destroy weed-seeds.

In short, dung should be used as starter for compost preparation rather than for preparing cattle-dung manure out of it. This will result in a two-fold advantage. The manure will be of good quality, free from weed-seeds, and the total output of manure would be considerably increased because of the use of a large quantity of additional refuse material.

—*Indian Farming*, Vol. VII, No. 4, April 1946.

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FURTHER NOTES ON AERIAL RECONNAISSANCE FOR FOREST OFFICERS

By A. L. Griffith, I.F.S.

(Central Silviculturist, Forest Research Institute, Dehra Dun)

In the issue of May 1946 I published some ~~notes~~ on an air reconnaissance of the Thar desert of Sind together with some photos taken or the trip. This was in easy country and the object of doing the reconnaissance by air was to save time and money and to try out the possibilities of an amateur taking photos from the air without any special training and equipment. The venture proved a complete success.

I have recently been fortunate enough to gain further experience of this type of work under quite different conditions and in entirely different country from the Thar desert.

In February last, while on tour in the North-West Frontier Province with Mr. N. G. Pring, the Conservator of Forests, we wished to see the state of the forests in the many catchments off the river Indus in the Amb-Chilas-Gilgit area, for erosion in these catchments is liable to have a large effect on flooding and silting in this mighty river and hence cause trouble in the irrigation systems lower down, systems which irrigate many lakhs of acres of cultivation.

The area is very difficult country with the Indus flowing at an elevation of some 3,000 to 4,000 feet through precipitous valleys the sides of which rise to a general level of about 10,000 to 15,000 feet with peaks of over 20,000 feet. The highest mountain in the neighbourhood is the awe-inspiring Nanga Parbat (26,620 ft.). The country consists of states, tribal areas, agencies and even disputed areas. Parts of it are almost impossible to enter without a small military expedition.

In consequence, it was decided to see it from the air and the flight was made at the request of the government of the N.W.F.P. and was carried out by the courtesy of the Royal Air Force.

The party consisted of Messrs. Curtis (Secretary to Government, Development Department, N.W.F.P.), Pring (Conservator of Forests, N.W.F.P.) and myself and we flew from the aerodrome at Peshawar. The route followed is shown in the accompanying rough sketch map on page 238 and was *via* Nowshera to join the Indus just north of Amb, and thence up the Indus valley to Chilas. On the return journey we cut west across the ranges some miles to the north of the Black Mountain to Saidu in the Swat valley and thence down this valley to Malakand and so back to Peshawar *via* Dargai. We thus saw the southern part of Swat, Hazara tribal areas (on the Indus left bank) Indus Kohistan, Chilas territory of the Gilgit Agency and part of the Malakand Agency.

The plane was an Anson. This is two engined aircraft and was fitted with six bucket seats in a midships cabin. It was flown by an R. A. F. crew of three, consisting of a pilot, a navigator and a wireless operator. It is not a particularly suitable type of plane for the purpose as from the cabin there in no view straightforward and the side view is restricted by the wings and tail. Good vision was therefore largely straight out of the sides and it was not easy to see the country as one approached it and hence it was difficult to see suitable subjects for photographs before the moment they had to be taken. In addition, the exposures had to be made through rather small dirty glass windows. The camera used was a 9×12 cm. size folding Zeiss Ikon with a film pack adapter. Incidentally this was the camera that proved unsuitable for photography from a Gipsy Moth plane in the desert last year but it was quite satisfactory under the conditions of this flight. I quickly found that the most suitable place on the plane for photography and also for general observation

ROUGH SKETCH OF KOHISTAN FLIGHT

Scale *1 inch = 15.78 miles*

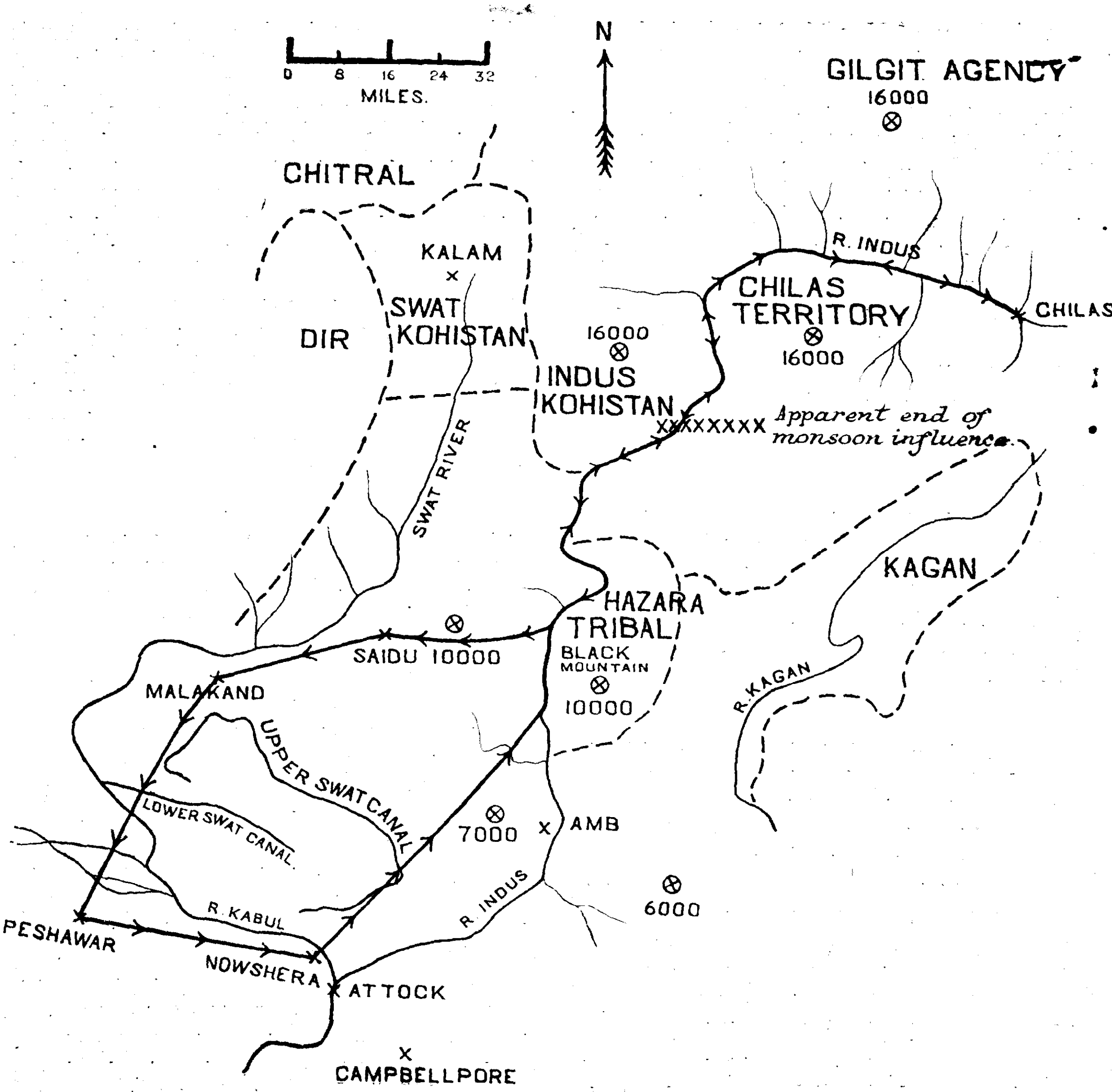
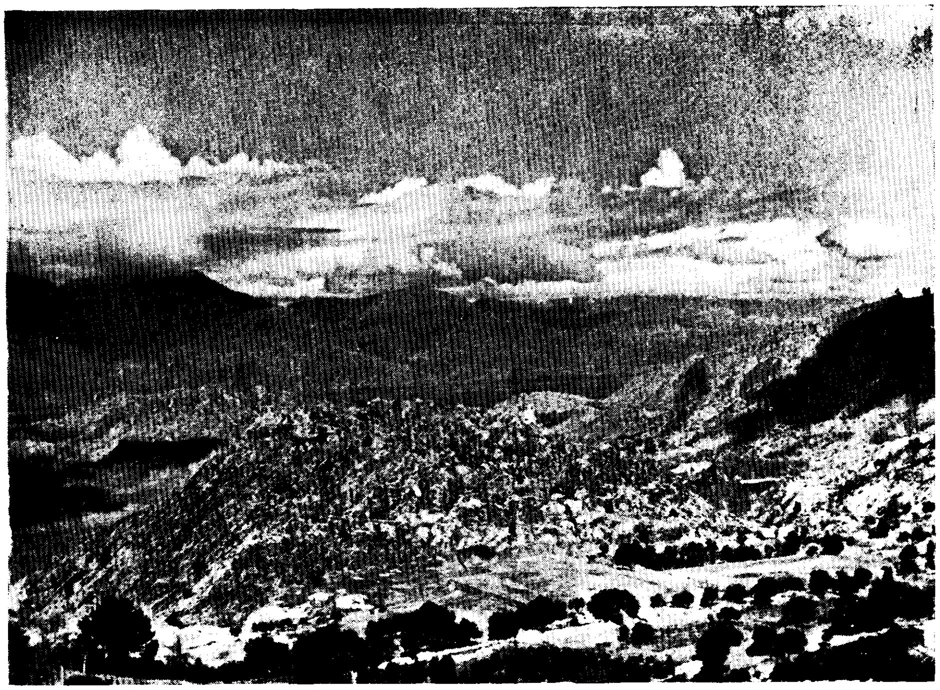


Fig. I



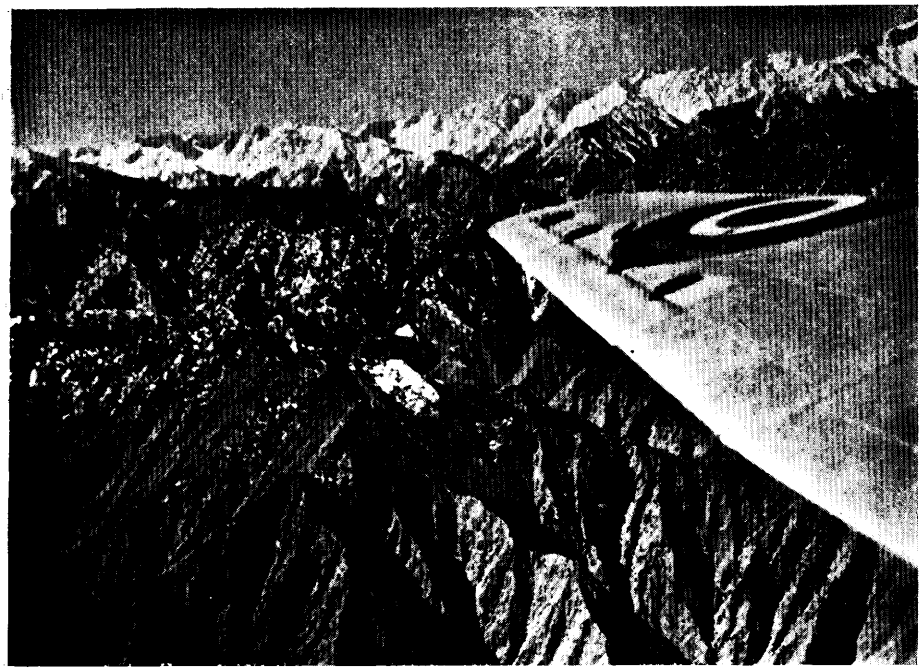
A ground photo of the beginning of the Swat valley from Malakand. Levy posts guarding the road can be seen on the near hill. **Photo: Author.**

Fig. II

A ground photo of the Malakand catchment and the beginning of the Swat valley. The vegetation is open forest with **Pinus longifolia, Olea cuspidata** and **Dodonea viscosa** as the dominant species. **Photo: Author.**

The effect of aspect on the vegetation

Fig. I



A generally northern aspect on the left bank of the Indus. The forest of the lower slopes is oak of mixed species and above this is **Cedrus deodara** with a little **Pinus excelsa**. **Photo: Author.**

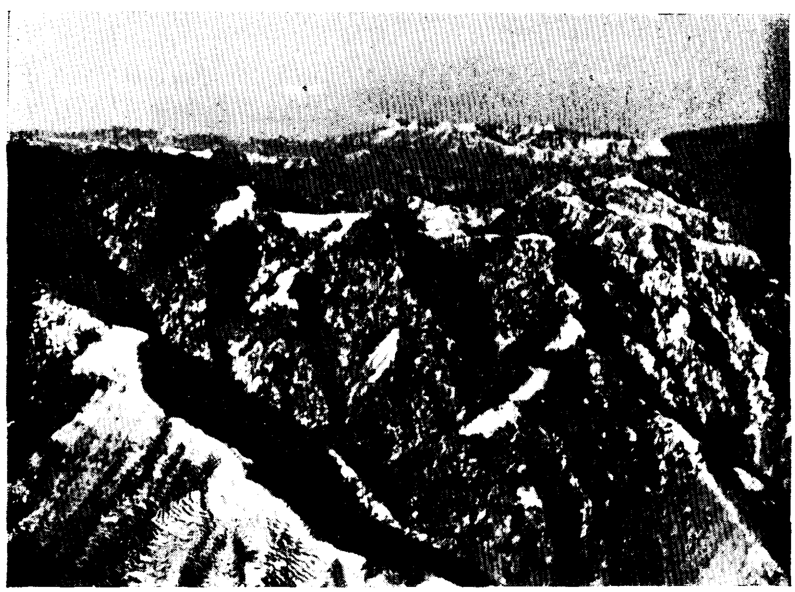
Fig. II

A poorly forested side valley with a generally southern aspect on the right bank of the Indus nearly opposite to Fig. I. Note that the oak goes several thousand feet higher than in Fig. I and the deodar and blue pine belt hardly exists at all. **Photo: Author.**

Fig. I

In spite of the precipitous nature of this valley on the left bank of the Indus it is quite well wooded.
Photo: Author.

Fig. II



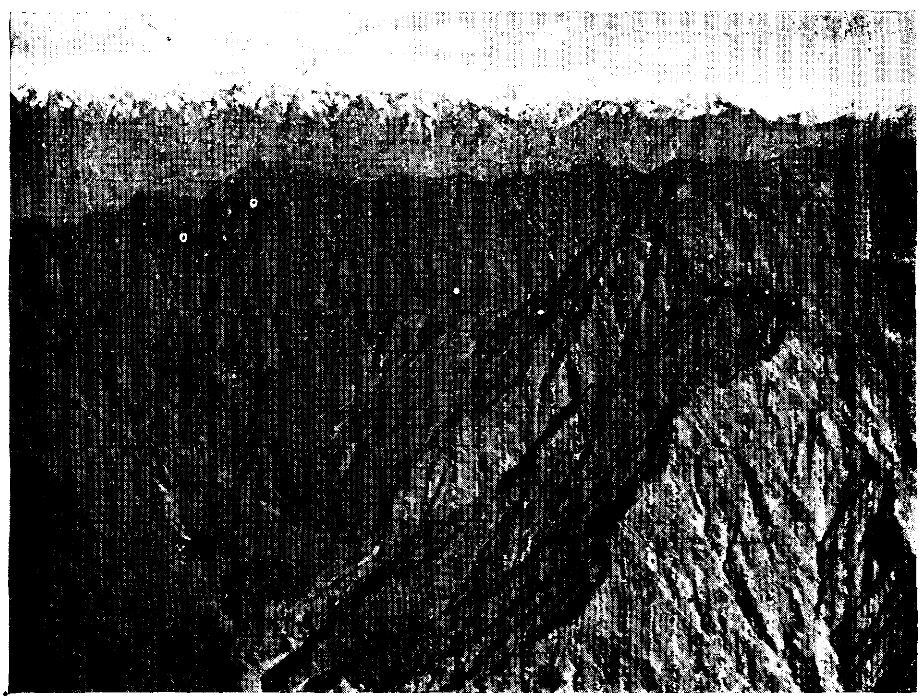
A well forested catchment on the right bank of the Indus which again demonstrates the effect of aspect. Note the terraced cultivation in the left hand bottom corner of the picture.
Photo: Author.

The effect of aspect combined with that of the monsoon influence

Fig. I

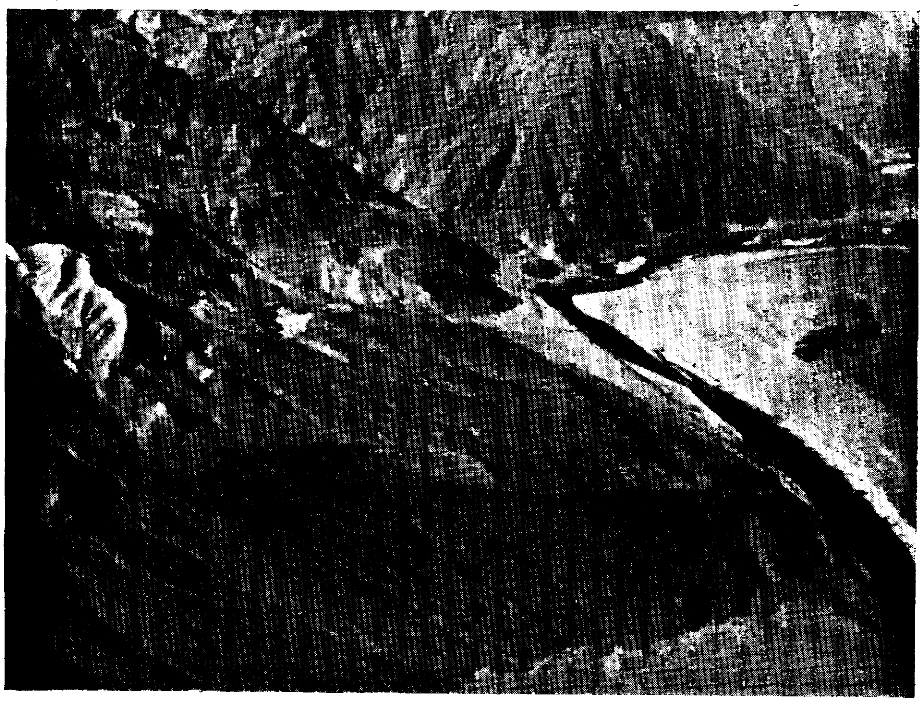
A generally northern aspect on the left bank of the Indus where the influence of the monsoon is still felt. The forest is chiefly **Cedrus deodara** and **Pinus excelsa.** **Photo: Author.**

Fig. II



A generally southern aspect on the right bank of the Indus almost opposite Fig. I, but where the influence of the monsoon is scarcely felt. The vegetation is sparse scrub mixed oak. **Photo: Author.**

Fig. I



Looking west down the Indus near Chilas. Note the large detrital cone in the foreground. **Photo: Author.**

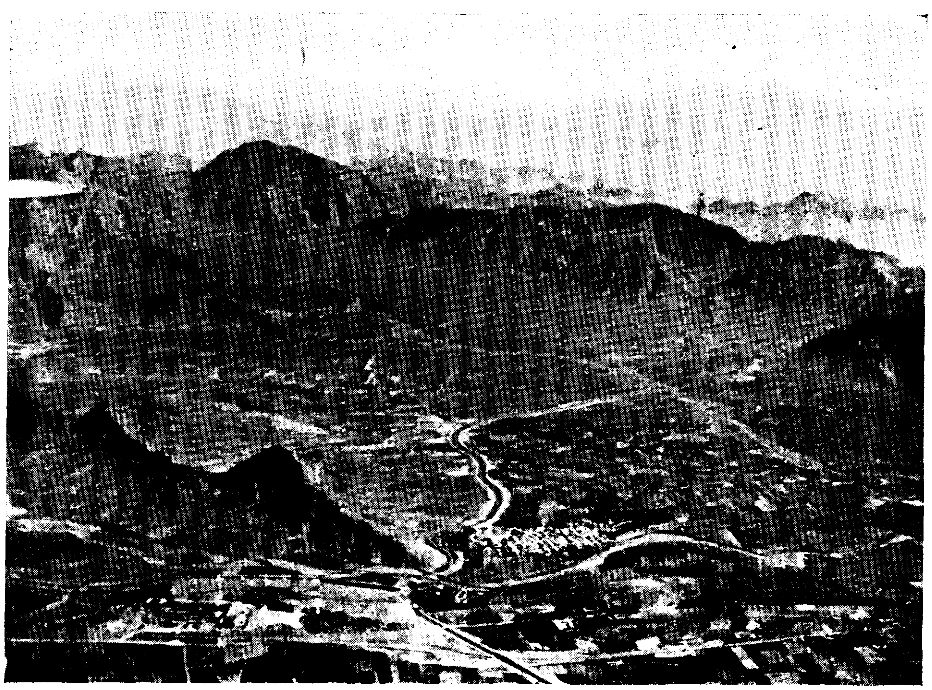
Fig. II

A quite well forested catchment with a northern aspect on the right bank of the Indus near the end of the monsoon influence. The vegetational zones of oak, deodar and blue pine are well marked. **Photo: Author.**

Fig. I

A high well forested catchment on the left bank of the Indus in the Hazara tribal area. The forest is **Cedrus deodara** and **Pinus excelsa** and above this a little **Abies pindrow** and **Picea morinda**. **Photo: Author.**

Fig. II



Dargai and the Upper Swat Canal just after it emerges from the hills through the tunnel at Malakand. **Photo: Author.**

and note taking was the "bathroom" at the rear of the cabin. Here one had a central seat to sit on, the widest angle of side vision on the plane and plenty of room round on the floor to put photo gear, note pad, maps, spare clothing, etc.

The day was clear with good visibility. The greater part of the flight was done at an elevation of 9,000 to 10,000 ft. and as already noted the river was below us at about 3,000 to 4,000 feet and the hills above us at 10,000 to 15,000 feet. I used a standard Weston exposure meter and with apertures of F8 to F11 and using a light yellow filter exposures generally varied from one-fiftieth to one-hundredth of a second. The film packs were Kodak Super XX high speed panchromatic. The cruising speed of the plane was roughly 125 miles per hour.

In Plates 6 to 11 are shown some photos to demonstrate the sort of detail that comes out. Two of the photos (Plate 6) were taken on the ground and are given to illustrate the difference between ground and air photos of somewhat similar areas in this type of hill country.

From the forest point of view, in general, the vegetation is very sparse in lower Swat and the adjacent Indus valley areas but gets better as we go north away from civilisation, until at about Patan the effect of the monsoon is apparently lost and the vegetation starts getting sparser and sparser again. In general the Indus left bank is quite well forested while the right bank is very bare. This is largely also the difference between north and north west aspects as opposed to south and south east aspects and on the latter the corresponding vegetation is roughly some 2,000 feet higher up the slopes than on the former.

In this connection it was also noticeable that the lower slopes of the valleys on the left bank were very much intensively cultivated than those on the right bank.

The general arrangement of the vegetation is that near the river the land is either bare or cultivated. As we go up, we first come to oak forest (*Quercus* spp. mixed) and then to deodar (*Cedrus deodara*) with a little blue pine (*Pinus excelsa*). Above this belt there is a little fir (*Abies pindrow*) and spruce (*Picea morinda*) and then the snow. The oak and deodar belts are the main features. Beyond the big bend of the Indus river to the east as we proceed towards Chilas and are out of the monsoon influence the country rapidly gets barer and barer. The effect of aspect is also shown in that the influence of the monsoon appears to stop some twenty or thirty miles further south on the right bank than it does on the left bank of the river.

In one area to the south of big eastern bend of the river (roughly between Patan and Sazio) on both banks there is a great deal of dead wood both standing and lying in the deodar forests. This is probably due to extensive fires.

This flight once again amply demonstrated the value of air reconnaissance. It is possible to get to Chilas on the ground but it would take some 14 to 16 marches of hard going each way and most of this is up the Kagan valley. Such a journey would however give very little idea of the general problem for in these precipitous valleys the mule track goes along near the river bed and one sees little or nothing except the bottom of the valley one is walking or riding in. This was particularly my own experience some years ago when I walked some considerable way up the Kagan valley. In such marches one has no idea of what the vegetation of the next valley or next series of valleys is like.

The photos of Plate 7 demonstrate the effect of the difference of aspect on the two sides of the river. Fig. 1 of Plate 8 shows the precipitous nature of the hills while Fig. 2 of the same plate illustrates the effect of aspect on a hillside (a particular feature of this Fig. is the terraced cultivation in the left hand corner of the picture).

Plate 9 demonstrates the difference between the two banks of the river as one begins to get out of the monsoon influence. Fig. 1 of plate 10 shows the lower slopes near the river quite close to Chilas and Fig. 2 of the same plate gives quite a fair idea of the general vegetational zones that one is dealing with. The last plate (Fig. 1 Plate 11) shows part of the well forested Black Mountain in the Hazara tribal area while Fig. 2 of the same plate is a picture of the plains near Dargai as one leaves the hills of Malakand and comes out towards the Vale of Kashmir. Prominent in this photo are the Dargai Fort and the Upper Swat Canal.

I would once again emphasize that an air reconnaissance of this sort is complementary to and not a substitute for a ground inspection. It is essential to see the vegetation on the ground before one can get a full and correct appreciation from an air survey. The point is that such a combination of ground and air work gives information in a short time that would take months and months to collect on the ground alone.

In conclusion I would like particularly to point out that such an air reconnaissance and the taking of photos from the air for general reconnaissance purposes require no special skill, training or equipment that is not within the reach of the ordinary normally trained techincal forest officer, and I would urge forest officers in general and particularly those dealing with such problems as working plans, erosion schemes, reconnaissance of new or difficult areas etc. to have a look at their country and problems from above. From my own practical experience I can assure them that it will give them new ideas and a far more complete appreciation of their problems.

India is a vast country with vast problems. It is also a conservative country. To appreciate and get on with the tackling of these big problems we must make use of modern methods. The planners must of necessity always be ahead of those who carry out the plans and we must realize the every day uses that the aeroplane can be put to that cannot be had from the bullock cart, the railway train or the motor car.

I would like to take this opportunity of thanking Mr. Curtis, Mr. Pring, the Government of the North-West Frontier Province and the Royal Air Force for making this flight possible. Quite apart from the "technical shop" aspect of the flight the sight of the mighty Himalayas from the air and the crowning glory of Nanga Parbat rising up into the skies like 27,000 feet of snow-clad cathedral is a sight and an experience that one will never forget. The beauty and grandeur seen on that clear winter morning cannot be described, it was just an awe-inspiring and never to be forgotton glimpse of the beauty of nature.

Readers interested in this subject should refer to "Aerial reconnaissance for forest officers" in the issue of May 1946 and to "Air Survey and Soil Erosion" in the September 1946 *Indian Forester*. They are however reminded that I am dealing entirely with the possiblities of such work by ordinary forest officers for ordinary forest work. I am not dealing with detailed accurate air surveys which are quite a different matter.

The subject was also referred to and discussed by the seventh silvicultural conference in October/November last year (1946) when Item 6—The Technique of Soil Erosion Surveys, was considered.

The relevant resolution adopted by that conference was :—

WHEREAS (*e*) Aerial reconnaissance has proved of special value in a preliminary appraisal of project areas and,

(*f*) more detailed aerial survey is of value in certain particular cases,

THIS CONFERENCE RESOLVES THAT—

(4) *The uses of detailed aerial survey might with advantage be applied to difficult and remote country, unsurveyed tracts, and where sheet erosion cannot be located from maps or by ground surveys.*

(5) *Aerial survey should be regarded as complementary to ground survey with which it must be correlated.*

CASUARINA PLANTATION TECHNIQUE IN THE MADRAS PROVINCE*

By M. S. Raghavan,

(Provincial Silviculturist, Madras)

SUMMARY.—Attention is concentrated only on Casuarina plantation technique in a few divisions which have been selected as typical. Therefore, it has been necessary to omit mention of several divisions, in the interests of brevity, though it is known that valuable work is done in them. The justification is that their work can be classified under one of the types chosen. The sources of information are mentioned. It is stated that only typical areas, representing different types have been included in the report.

The variations in climatic and soil conditions under which casuarina can be grown have been indicated. The interaction of casuarina growth and soil moisture are mentioned. The season for seed collection, the method of collection, the agency of collection, and the preservation of seed have been stated. It has been stated that very tall plants have sometimes disproportionately shallow and insufficient root systems. The variation in growing seasons between dry and moist localities is also indicated. The uncertainty of natural regeneration by direct seed fall, by coppicing, and by layering, and the consequent necessity for artificial regeneration have been mentioned.

Artificial regeneration is either by selecting barren sandy coastal areas, or by clearfelling and burning interior areas with some growth, and entire transplanting with suitable soil preparation, of tall nursery-raised plants in pits.

The rotation for Casuarina plantations in the province varies from six to ten years, but in one division the district forest officer is expected to use his discretion after ten years and to extend the rotation up to fifteen years if necessary.

The preparation of the planting site, including felling regrowth, uprooting stumps and roots, heaping, burning, alignment, staking, pitting, and fencing have been discussed. Details of nursery technique have also been given. The best espacement, the best size of transplants, the best season for transplanting, and the actual method of transplanting have been defined. The need for watering, the number of years when watering is necessary, the periodicity of watering, and the quantity of water required, have all been reported on. In general, planting entire nursery raised six months old transplants, about two feet in height at an espacement of 7 by 7 feet in prepared one foot cube pits, in June or July at the beginning of the south west monsoon, followed by adequate watering on non-rainy days for a period of one to three years (except under the dry technique of Mysore) under a rotation of seven to ten years have been favoured.

Post plantation operations such as soil aeration, weeding, climber cutting, pruning, and replacement of casualties, have been described. The advantage of horse gram *kumri* has been considered. The necessity and degree of thinning has been discussed. It is considered that for fuel plantations on a short rotation, with an initial espacement of 7 × 7 ft., thinning is unnecessary.

External dangers from animals, insects, fire, and fungus have been discussed, and remedies suggested.

As the yield varies very considerably, no details have been furnished.

Introduction

In writing these notes, I have had access to all available literature in my office including Troup's *Silviculture of Indian Trees;* Troup's *Exotic Trees of the British Empire;* Dr. Beeson. Mr. V. Subrahmanya Iyer, Mr. Stebbing, and Mr. Fletcher for notes on insect pests; Popert's "Notes on Casuarina Planting"; Aldrich Blake's "Fixation of Atmospheric Nitrogen by Bacteria living symbiotically in root nodules of *Casuarina equisetifolia*"; Mr. G. Jogiraju's "Note on Casuarina Plantations in the Vizagapatam District"; current working plans of Lower Godaveri, Nellore, South Salem, and South Canara division; selected as representative types various annual reports including those on silvicultural research in the country; Madras province conservators' inspection notes on

*Paper read at the 7th All-India Silvicultural Conference, Dehra Dun (1946), on item 14—Casuarina Plantation Technique.

Casuarina producing divisions, issued from time to time; and miscellaneous information filed in my ledger files, including a note by Mr. J. M. Sweet on "Casuarina plantation technique in Mysore"; and several office files. I am also obliged to Mr. K. R. Venkata Row, district forest officer, Bangalore, who during one of my visits, gave me valuable information on Casuarina technique in Mysore, which I have freely used in these notes. After anxious selection from the mass of information available, I have compressed all pertinent information, and have found a new setting for them, so that all the information may form a homogeneous whole. I therefore claim no originality for any information incorporated here. Though, wherever possible, I have acknowledged in the text my source of information, the new setting and compression has not always allowed of such acknowledgment. With apologies to the observers and writers whose opinions have been incorporated in these notes, without individual acknowledgment in the text, I acknowledge at the outset my great indebtedness to each one of them in the compilation of these notes. As typical areas have been considered, others have been left out in the interests of brevity of report.

We, specially city dwellers, have been recently in the throes of a country-wide fuel shortage and an adequate fuel supply has assumed prime importance. Large areas are being put under fuel species, of which casuarina is one of the most important. Casuarina plantations have been raised under varying conditions of soil and climate. These variations coupled with the variation in technique, have led to varying degree of success. The time has therefore come for a study of the different conditions which effect the success of casuarina plantations. The following note merely aims at giving as briefly as possible, a few examples of the different techniques employed in different localities in the Madras province. Passing reference is also made to the very interesting dry technique followed in Mysore for raising casuarina plantations. Opinions are not expressed, as the subject is still *sub-judice*, experimental work having been commenced in the Sriharikota island of the Nellore forest division in the Madras province, under an assistant conservator of forests, who is posted as the silviculturist's assistant for the conduct of research on the silviculture of *Casuarina equisetifolia*. Here every aspect of casuarina plantation technique is investigated by latest research methods.

There are over twenty species of Casuarina, of which a few have been introduced into India. *Casuarina equisetifolia* is the one species that is most extensively and very successfully raised in several places in the Madras province. It is a large quick growing evergreen tree, but is short lived, probably not living far beyond fifty years. Though it is essentially a littoral species, thriving best on loose fine sand close to the sea, in warm to hot climates with a heavy rainfall, it has also been grown successfully under other conditions of soil and climate in this country. Thus it has been successfully grown in South Canara district on gravel overlying laterite, though it is admitted that the rainfall of about 160 inches per annum is very favourable. It has also been grown in the Mysore State on red loam with a rainfall of only 30 to 40 inches per annum. For details of its silviculture a reference to Troup's *Silviculture of Indian Trees* is invited; and for brevity the information recorded there is not repeated in these notes.

Casuarina is a valuable fuel, with a high calorific value, very much in demand where it can be made available. It can grow on the sea board in otherwise unproductive sand, and is of very great use in arresting the landward drift of sea sand. Profitable plantations have been successfully raised economically on and near the sea-shore, conferring both these benefits. Where not excessively planted as to be monotonous, there is also an aesthetic value.

Casuarina equisetifolia is a light demander, and for satisfactory development it is said to require a free circulation of cool breeze through the plantation. In sandy areas, where there is a tendency for the water table to vary within wide limits; the species develops a long tap root to tide over the dry season when the water table is low.

Soils

Casuarina equisetifolia is grown on a wide range of soils. For example in the Sriharikota island of the Nellore division, it is successfully grown on deep infertile sand. The secret of its success in such infertile localities is perhaps the existence of nitrifying

bacterial nodules on its root system which help in nitrogen fixation, the sandy soil merely serving for support and as a reservoir for the necessary moisture. Sandy loams covered over by one or two feet of drift sand, and with the water table at a depth of three to six feet during summer, have, according to Mr. Jogiraju, been found to show the best growth. The ideal conditions therefore appear to be looseness of soil, and the presence of a sufficient amount of moisture at a moderate depth below the surface. Once Casuarina has been raised on poor infertile sand, the sand is protected from being blown away, and soon gets covered with vegetation such as *Ipomea biloba*, and in course of time improves by admixture with decayed vegetable matter such as needles, etc. It should however not be taken that all sandy soils are suitable for casuarina. The research report of Bihar and Orissa for 1930/31 on examination of the causes for the heavy mortality observed in the Puri Casuarina plantation, suggests that *it* seems likely that there is some correlation between the percentage of coarser sand particles and the intensity of mortality, as the area where casualties have occurred contains a higher percentage of coarser soil particles than the part of the plantations which is free or almost free from casualties. In the interior as on the Mysore plateau, the species is raised on red sandy or gravelly loams also, though the growth is perhaps a little less than what may be expected under ideal conditions. In Mysore a blank area of poor scrub type with a red loamy soil about three feet in depth is considered sufficiently satisfactory. There casuarina has also been observed to do well on lateritic soils, provided the laterite was overlaid by about three feet of disintegrated soil. Areas where the laterite is nearer the surface than about 2½ ft. are avoided for Casuarina planting. In Mangalore, there are no reserved forests on the sea sand, and the forest department is therefore compelled to do its planting on inland areas, where the soil is lateritic. Even here, if the disintegration of the laterite has given us at least a gravelly soil of about 2 feet overtopping the laterite, success has been achieved, especially where the area has previously borne a good quality natural forest growth. One of the great advantages in these South Canara forests is the heavy rainfall, which is about 160 inches per annum.

Mr. Jogiraju observes that some plantations in Vizagapatam district are found on moderately saline soils, varying in texture from loams to clays, and the growth is in some cases quite fair. But more recent observations by Mr. D. L. Sathe in the Kandikuppa plantations of the lower Godaveri division, followed by a chemical examination of soils, seem to indicate that alkalinity of soils may cause failure in plantations. It therefore appears that the salinity of soils should not extend to alkalinity. The Mysore forest department considers clayey soils as unfit, nor are acidic soils fit for regeneration with Casuarina. The Madras forest department also agrees with this view.

Mr. Jogiraju has observed that in some private plantations casuarina trees are growing well in highly waterlogged situations and even in places where water accumulates in the rainy season, and stands to a depth of three feet for some months. Here the trees throw out long adventitious roots which float on the water to obtain the air required. When water subsides, the roots come into contact with the soil, penetrate into it, and grow like ordinary roots. It has been observed however in the Sriharikota plantations of the Nellore division and in the Padugais that if *the flooding is such that the terminal shoots* of small casuarina plants are submerged for more than two or three days the casuarina *plants are killed. If the depth of water is* not sufficient to submerge the plant to this extent, submergence of the stem for such a short period does not kill off the plant, provided the water drains off rapidly. Waterlogging does not appear to be good for casuarina trees. For this reason, attempts to grow casuarina in localities liable to submergence in Sriharikota island, include mound planting.

Mr. Jogiraju draws *attention to an evil* of casuarina planting. It gradually exhausts the moisture in the soil, and effectively lowers the water table. It has been his experience in some places that the water in the wells in and around plantations has gone down or completely dried up by the time the plantations were cut down, in the tenth or eleventh year, rendering the watering of the plants in the second rotation very difficult.

Flowering, Seeding, Seed Collection, Seed Supplies

The season of flowering and seeding varies with the locality. In South Canara

division the best month for collection of seed is September-October. On the east coast trees have been observed to produce seed as early as three years after planting, but seed from such young trees is unsuitable for sowing in nurseries, or *in situ* as the germinative capacity is considered to be poor. Seed should therefore be collected from trees which are about 5 years old or older. In the South Canara division, mother trees 8 to 15 years old are recommended for seed collection. There are many such trees on road margins, and some in private plantations.

In the Vizagapatam district, casuarina trees have been observed to flower from July to August, and the cones ripen in December to April.

In the Nellore district, they have been observed to flower and seed twice a year, once in May-June and again in December-January. The general seeding time in the Nellore district, however, is December-January.

The seed should be collected only when the cones are ripe, but before their dehiscence, from well grown mature trees. The brownish colour of the cones indicates their fitness for collection. The cones are collected usually in the afternoon, and they are spread on a clean floor or on mats next morning, and allowed to dry in the sun for 3 or 4 days. The scales then open, and the seeds are shed on the mats. The axes of the cones and scales, are then picked, out, and the seeds dried for a further period of 2 or 3 days. At this stage there is risk of the minute seed being blown away by wind. But this can be guarded against by covering the seed with a cloth, weighted or pinned down at the corners. The dried seeds are stored in earthenware pots, the mouths of which are tied with cloth to protect the seed from being carried away by ants. The addition of a small quantity of camphor to the seed in the pots is a further protection against insects. Neither the cones nor the seeds should be exposed to night or early morning dew. Storage of seed in pots in smoky kitchens is also advocated.

A full gunny bag of cones will yield about $1\frac{1}{4}$ to $1\frac{1}{2}$ lbs. of seed. One and a half lbs. of this seed when cleaned will give about 1 1/10 lb. of cleaned seed. It may therefore be stated that a full gunny bag of cones will yield about one lb. of cleaned seed. An ounce of cleaned seed contains about 21,500 seeds.

If it is desired to collect large quantities of seed, Mr. Jogiraju suggests the use of idle indigo vats if any are available in the vicinity, as they will protect against the seed being carried away by wind. Mr. Jogiraju also recommends that only seed that is shed on the first and second days in bright weather should be collected for use, as they are the best.

There are private seedsmen who sell casuarina seed ; but the writer has had complete failure with some batches of seed bought from private seedsmen, though in parellel experiments he has had success with seed collected and supplied departmentally from the Nellore division. He therefore is justified in uttering a warning, that it is best to obtain seed required for government purposes as far as possible from government plantations, or from very well known reliable seedsmen. Otherwise there is risk of seed from immature trees or from immature cones on mature trees being bought, resulting in total loss of all costs incurred on nursery work.

Seedling and Post Seedling Stages

Mr. D. L. Sathe, has observed in the Nellore division while examining some seedlings pulled out from nursery beds, that the growth of the root did not keep pace with that of the stem. Some plants were as much as seven feet in height, but their roots were only about six inches long, while the shorter plants also had the same length of root. It would therefore appear that the height of a plant even under plantation conditions may not be a safe criterion to determine the depth of the root system, or for judging when watering may be stopped.

It has been observed that growth of the casuarina plants ceases from February to July (the hot season), begins some two or three weeks before the rains begin, and continues through the rains and the cold weather, till the commencement of the next hot season in February. On the other hand in wet localities growth stops during the cold weather from October to February and then begins and continues through the dry hot weather and rains. The nett result however is that casuarina plants grow more rapidly in the wet localities provided there is no waterlogging than in the dry localities.

Natural Regeneration

By Seed—According to Troup natural regeneration of casuarina by seed, has in eeneral been scanty or absent in coastal plantations in India, though in North Canara natural seedlings have been observed in large quantities in open spaces along the edges of old plantations towards the end of the monsoon. So far as observations go, essential conditions for the appearance of such natural regeneration are (1) abundance of light (2) porous sandy soil free from weed growth (3) absence of heavy rains during germination and early life of the seedlings, and (4) sufficient moisture in the soil to prevent mortality by drought during the first two or three years.

By Coppice.—According to Mr. Osmaston (*Indian Forester*, December 1934), though pollard and coppice shoots are occasionally observed, such regeneration appears to be temperamental, and is produced only when the stumps are protected from sun and wind. It has been observed that stumps will coppice for certain, if at the time of felling, at least one branch is left below the cut to maintain the vitality of the stool.

By Layering.—These low branches often sweep the sand, and in exposed places blown sand tends to accumulate and bury them at some points. After some undetermined period of time these branches develop independent root systems, and produce vigorous vertical shoots. Such layering is said to be prominent where the plantation has to resist sea winds and driving sand that blows inland. It is therefore considered possible to obtain success in regenerating casuarina at Puri by coppice shoots and by layering, and thus to avoid the cost of artificial planting.

Artificial Regeneration

But in our Madras plantations, the above methods are yet of doubtful value, especially as the period for the production of coppice shoots or of layered plants is indeterminate; and we have therefore to depend entirely on artificial regeneration. Artificial regeneration by seed has not been found successful. Therefore we have recourse to entire transplants raised in nursery beds. The silvicultural system followed is therefore clear felling, and regeneration by planting nursery raised entire transplants.

Rotation

This is very difficult to determine. In the past there has been a wide variation between the 10 years rotation adopted in Madras and the 30 years adopted in North Canara. The rational determination of rotation will consider the culmination of increments in a plantation. This will depend on espacement, and several other considerations. Mr. Jogiraju observes that on data are available as to the age up to which the trees continue to show the same annual weight increment per acre as in the first ten years, and that Mr. W. A. Millet in a note on casuarina plantations on the North Canara coast writes that the annual increment was largest in the 33rd year, figures having been noted for forty years. On this basis a thirty years rotation has been recommended for North Canara, but this was a case of wide planting, and the increments were those of individual trees. In close planting, the maximum mean annual weight increment per acre will be reached much earlier, unless the trees are regularly thinned from the earliest age. Also from a commercial point of view a quicker though somewhat smaller return is of greater advantage than a larger return after a long waiting, especially when the need for fuel is great.

The problem has been discussed on the following lines in the Nellore working plans.

(a) The mean annual increment (volume) of the crop culminates at the age of six years in the eastern half of plantations along the coast, but on the western half where the rate of growth is comparatively slower in the initial years the increment does not appear to culminate till the age of eight and a half.

(b) The size of billets required for the Madras market is about 15 inches in girth, and the average tree in the crop does not reach the requisite size at breast height till the age of $7\frac{1}{2}$ in the eastern and $8\frac{1}{2}$ in the western half of the plantation.

(c) Since the object of management is to produce the maximum quantity of casuarina possible, any shortening of the rotation, will proportionately increase the area to be planted up

if the level of annual production is to be maintained, which under present conditions of labour it will not be possible to undertake.

(d) Loss due to dryage would be more in younger than in older crops which would affect to some extent the financial return adversely.

So, silviculturally the proper rotation is seven years, but economic and financial considerations indicate a longer rotation. However a rotation of seven years will be adopted tentatively, and the position will be reviewed at the end of three years.

Thus the rotation as prescribed at present for the Sriharikota plantations is seven years. The rotation is ten years for the casuarina plantations in the Lower Godaveri, South Canara, and South Salem (Padugai) divisions. In the South Canara division, however, it has been prescribed that about the tenth year the district forest officer will decide whether the plantation is fit for felling from the financial point of view. If the rotation has to be raised, the maximum will probably be fifteen years. This may be compared with a rotation of four to twelve years in private plantations in the South Canara division, and twelve years and over in private plantations near the Padugais. The differences in rotation are attributable to different objects of management which obviously aim at early small returns in private plantations near Mangalore, and something more than the ordinary firewood prices in the Padugais. In Mysore the rotation adopted appears to be ten to twelve years. They sometimes expect a coppice rotation to follow a seedling crop. If there is no coppice rotation, they leave the area fallow after felling or take a field crop, for about three years. If within the period of twelve years the demand for fuel justifies it, a thinning is also done by the removal of suppressed stems.

Seed Collection

Some information has already been given on seed collection. The seed weight is about 21,500 to the ounce. The seeds retain their vitality for a few months, and to some extent for a year. Tests at Dehra Dun gave a fertility of only 5 per cent after one year, but after eighteen months the fertility was nil. It is therefore best to collect seed shortly before it is actually required for sowing.

Selection of Site for Planting

All available information on the requirements of casuarina with regard to site and moisture have been summarized. It is therefore not considered necessary to repeat the information here. Careful selection is necessary for economical plantations.

Preparation of Site for Planting

In sandy soil, free of all vegetation, no preparation of site is required, but in land covered with vegetation, some preparation is necessary. The first essential is the removal of the existing growth. What is saleable will of course be sold, either standing to be felled and removed by contractors, or cut departmentally and then sold. In general the unsaleable material is left in situ. As dead and dying roots are in some places said to attract white ants, and these white ants then damage the casuarina seedlings, uprootal of the roots of the felled trees is considered necessary. If there is any coppice growth this is also cut and allowed to dry. All the stuff obtained thus is spread out to dry, heaped and burnt. In Mysore, since only bare areas are taken, these operations are estimated to cost only about Rs. 1/8/0 per acre if done departmentally, but in other places the cost, specially of uprooting is high. Economic production of fuel involving cheapening of costs, indicate omission if possible of the uprootal of roots in the ground.

In the Padugais, as soon as removals have been completed, the coppice growth on the area is cut and allowed to dry on any material that may have been left unremoved by the contractor. Such material as this, and as may be on the ground including undecomposed casuarina needles if any, are burnt in Nellore, the Padugais, and the South Canara district plantations. A hot burn is considered in South Canara as of vital importance.

In Mysore government plantations, as they get some thunder showers in May, which sufficiently soften the soil, the soil is ploughed three times between June and September. According to them, experiments have shown that ploughing even after planting is perfectly feasible. It has been observed that while in several private plantations, casuarina died in large patches in the fourth or fifth year, there were no such casualties in the government plantations. This immunity is attributed to

the thorough ploughing in government plantations, while in private plantations they do not plough the entire area, but merely plant in pits. The basic principle appears to be the effective prevention of rapid run off of rain water, and the conservation of moisture. When done carefully under strict supervision, the casualties are said to be only about 2 to 3 per cent. Ploughing is done but no watering, and the cost of formation per acre by this method is said to be about Rs. 12/- per acre, against an expected revenue of about Rs. 200/- per acre in ten years.

Private planters in Guntur division, plough areas suitable for casuarina, raise field crops intensively for two or three years, and then plant casuarina, usually at a close espacement of 3×3 ft. Ploughing and the raising of such field crops is considered by them to be imperative. It may be that some bacterial reaction occurs by so doing, or it may be merely the better aeration of the soil, and absence of weeds, or again it may be moisture retention, that gives success in these plantations.

Alignment and Staking

In all localities, entire transplants of casuarina are planted in pits. These pits are dug at regular espacements in departmental operations, but by eye by private planters. The espacement differs, and will be discussed in a later paragraph. To ensure regular espacement of the pits in departmental operations, aligning and staking is done.

In Vizagapatam, in private plantations, the marking of the pits is reported to be done by running a plough at the required distance, first in one direction, and then in a direction at right angles to the first. The pits are dug where the furrows intersect.

In departmental operations in Nellore, a large planting area, say fifty acres is divided into four blocks of about 12½ acres each in extent. Each such block is divided into squares 49 ft. by 49 ft. 49 feet is selected as the planting espacement here is 7 ft. The planting rows are then formed by holding two ropes having knots at 7 feet sections, at right angles to each other. While the ropes are held thus, a cooly marks with a spade the position for planting. The rope is then moved forward and similar marks are made on the ground. A following cooly drops a stake at each pit site. The method is practically the same as is universally adopted for teak planting.

In the Padugais, where the soil is harder, stakes 1½ to 2 ft. long are driven firmly into the ground, at an espacement of 7×7 ft., by practically the same method. Then one foot cube pits are dug at the planting sites indicated by the stakes.

Fencing

During infancy, casuarina seedlings are susceptible to browsing and mechanical damage by cattle. Fencing at this stage is essential, and the fencing may have to be maintained for at least two years after planting. In the long run wire fencing may be most economical, but as wire fencing is not available at present, bamboo fencing, thorn fencing, brushwood, fencing, etc. are resorted to.

Nursery Technique

Though casuarina seedlings are sold by nursery men, there is some risk in buying them. In some cases, seedlings are forced up by manuring, and when such seedlings are planted out under forest conditions, they suffer, and heavy casualties result. Further there is unavoidable delay between removal from nursery and planting on the field, the delay being the time taken in transit. Great success with economy can be achieved by raising our own nurseries. Therefore, we have departmental nurseries for all our government plantation work. Nursery methods vary with the locality. The Kolaba method of raising nursery beds on small *pandals* is being experimented with, but there are no results to report here. A few other methods are described below.

Sriharikota nurseries.—According to the old working plans, the nurseries were to be started in December. This resulted in unwieldy plants by next September or October. There was a local practice of beating the tops of the seedlings with a heavy stick to retard their growth. This practice appears to have been borrowed from local casuarina plantation owners who plant at 4 ×4 ft. Though perhaps with their close planting the method was not unsatisfactory, the seedlings which had their leading buds damaged by the beating tended to be flat topped and slow growing in government plantations where the espacemeet was 7×7 ft. Hence, to get smaller plants at planting

time without the beating process, January of the year of planting is considered a better month than the preceding December, for starting departmental nurseries.

The nursery beds in Sriharikota are level with the ground—neither sunk as in Godaveri Lower division, nor raised as in the Padugais and elsewhere. The standard size for a nursery bed is generally about 50 ft. long by 3 ft. wide. In level sandy ground, there is no difficulty in getting beds of this length. But if due to special local difficulties, smaller beds have to be formed, there is no objection. The site is effectively fenced with such fencing material as is available, against domestic and semi-wild cattle. As the nursery sites are on sand, manuring or penning of sheep and cattle on the site appear essential for success. The penning is done for about three months before sowing the seed. At this time, the ground is thoroughly ploughed twice. With the ploughing the site is levelled. A two-foot wide path is left between every two nursery beds. As the actual planting may extend over a period of two or three months according to rainfall and availability of labour, the nursery beds are also progressively sown from January to the beginning of March or thereabouts so that the same size of transplants are available throughout the planting period.

Before sowing the seed, the beds are watered copiously. The beds are sown lightly with about four ounces of seed per standard bed, usually in the afternoon, when the weather is calm, lest seeds get blown off by wind. After sowing, the seed is lightly pressed down to the wet surface of the bed, and then covered thinly with sand, and casuarina twigs and needles are spread over the sand. The beds are watered both morning and evening, by watering cans provided with fine roses, about seventy-five gallons of water being given per standard bed. Germination takes place in about nine or ten days, when the twig and needle cover over the beds is carefully removed. Just after germination, it is difficult to differentiate between casuarina seedlings and grass. Misguided weeding must be guarded against at this stage. Watering with the rose can is continued till about the end of May, when the plants will be strong enough to withstand direct watering from pots. If during the period the plants appear crowded, a cautious pricking out into other similar nursery beds is indicated. But generally pricking out is not necessary. In about 6 to 7 months seedlings reach a height of about two feet, when they are fit for planting out. A nursery of about fifty beds is considered sufficient for raising about one hundred and fifteen acres of plantations, including replacement of casualties at a 7×7 ft. espacement, and costs about Rs. 290/- (Two hundred and ninety rupees) of which watering alone accounts for about Rs. 252/- at the present time, when four watering coolies are paid for three months at Rs. 5/- per month as pay plus Rs. 16/- as dearness allowance. The essentials of efficient nursery work are sowing lightly, watering judiciously and avoiding pricking out if possible. A standard nursery bed of 150 sq. ft. is expected to give about 2,000 to 3,000 utilizable seedlings.

Lower Godaveri division.—In the Lower Godaveri division, nurseries are established near sources of water, and at convenient places near the middle of each coupe, in December of the year that the coupe is felled. A plot of ground about two chains by two chains is selected, and fenced with casuarina brushwood obtained from the fellings. A well is excavated if necessary in the middle of the plot, and the nursery beds are arranged round the well. The nursery beds are excavated about six inches below ground level in pure fine sand. Before the seed is sown, sheep manure is spread lightly over the surface of the beds, which are then hoed to a depth of about nine inches, the manure being thus intimately mixed with the sand. When the hoeing is complete, these sunken beds are tamped with the hand, until the surface is fairly firm. The seed is then sown broadcast, and fine sand is sprinkled over the seed through a bamboo sieve until the seed is just covered. The beds are then watered profusely with a watering can fitted with a fine rose. Meanwhile the sides of the beds are watered and tamped to prevent the sand falling into the beds. Thereafter the beds are watered regularly both morning and evening, about one pot of water being used for two square feet of surface. The seeds germinate readily, and the beds are generally fully stocked. The beds are sown about the middle of December, and as there will be no planting out till the following July, congested patches of seedlings will be thinned by pulling out the poorer plants. The remaining seedlings are thus encouraged to develop a long

tap root. During planting, the nursery plants are dug up, not pulled out of the beds. When these beds are dug up, and healthy transplants are used for transplanting at the planting site, a sufficient number of healthy seedlings are replanted into nursery beds at an espacement of 9×9 inches, so that they may develop suitably for the replacement of casualties at the beginning of the rains the year after planting. Casualty replacements during the year of planting are done from nursery beds which are reserved for the purpose. Special precautions are thus taken for seeing that during replacement of casualties, we get plants which are on a par with the survivals in the planting site, so that uniformity of stocking may be achieved. In August of the second year, the nursery is abandoned, but planted with large transplants, so that it is amalgamated with the plantation. It is considered that it is of the utmost importance to remove the plants from the nursery without breaking the long tap root, and to plant them sufficiently deep so as not to bend the root. Deep planting, thus, is said to obviate the large number of casualties that occur otherwise. Any extra expenditure will therefore more than pay itself in increased percentage of success, and save second year watering.

South Salem division, Padugais.—An elevated well-drained site is chosen. The soil is dug to a depth of one to one and a half feet, and beds formed nine inches higher than the surrounding ground level. The sides of the beds are supported by bamboo splits. The standard size for beds is forty feet by four feet. Seeds are sown about the beginning of December preceding the year of planting. Beds are watered profusely during the first three months, by which time the seedlings are about six inches in height. They are then pricked out into other beds of the same size as the original ones at an espacement of three inches by three inches. It is calculated that for every two acres of plantation one such bed of pricked out seedlings will be required. After pricking out regular watering is done. By July when planting out is done, the pricked out seedlings are two to three feet in height. This height is considerd the best for planting out in the locality.

A new nursery technique is evolved recently, which aims at restricting the development of the tap root. In nursery beds prepared as above, during the process of formation, a layer of palmyrah leaves is intercalated about four to five inches below the final surface of the nursery bed. This layer tends to obstruct the downward development of the tap root and to deflect it laterally. This interference tends to make the root system shallow and bushy. It also tends to retain moisture from watering in the upper layers and to make more of it available for the plants, than in normal nursery beds where the water tended to percolate downwards and get lost. Data of the effects of this technique are not yet to hand, but results are watched with interest.

South Canara division.—Sandy or loamy soil is considered most suitable. The site is cleared of stones, roots, wood etc. About six to nine inches of soil is removed, and replaced by good fine sea sand. Beds raised about nine inches are used, the sides being supported by tarred casuarina poles. Sometimes as I saw in a nursery at Shiroor near Cundapur, the beds are at ground level instead of being raised. In ground level nurseries, there are drains about eight inches deep between the nursery beds, so that when water is filled into these drains, the nursery beds get water by percolation. It is considered essential that these drains should never be allowed to dry up, as otherwise there may be heavy damage in the germination stage. The raised nursery beds are watered in the normal manner from pots and cans. Seed is broadcast on the beds in September or October. Loose fine sand is carefully sprinkled over the seed in fine layers, and the sprinkling repeated till the sand is about one-third to one half of an inch in thickness. The beds are protected from the sun by day by *pandals* at height of two feet to two feet and a half. The *pandal* shade is removed at night. Beds are profusely watered in the morning before replacement of the shade, and in the evening after its removal, using fine rose cans. Germination starts in about six to eight days. When the seedlings are about one inch to an inch and a half in height, the shades are removed. When the seedlings are about two months old, they are about four inches high. They are then pricked out into other nursery beds of loose fine sand at nine-inch intervals. These beds are also provided with shade until the seedlings appear established, and vigorously growing. These pricked out seedlings are given copious watering twice daily for about fifteen to twenty days, and then watering is done whenever

the plants show a tendency to fade or wither. Watering in the hot weather is said to protect the nursery plants against white ants. The nursery cost for about fifteen thousand seedlings appears to be about forty rupees. Seedlings are dug out from the nursery, without balls of earth, tied in bundles of fifty, with plantain leaf packing round the roots, transported immediately to the planting site, and planted within twenty-four hours, when planting conditions are satisfactory.

Mysore.—Nursery beds are formed close to the area to be planted. In some places where irrigation facilities are available, the beds are watered by irrigation, and in such cases beds are about 2 inches below ground level, and the beds are very carefully prepared by clearing the soil of all stones, roots, etc. to a depth of at least one foot. Otherwise normal raised beds are formed about four to ten feet in length and about three feet in width. These beds are formed about six inches high by the usual method. A very sandy loam is often preferred, but if the soil is deficient in this respect, enough sand is added to the soil to bring it to the required consistency. About three lbs. of seed is sown broadcast on a bed about ten feet long by three feet wide. The seed is then covered with about half to one inch of pure sand. No further covering of brushwood or *pandal* is provided. The sowing is done in December-January. For about ten to twenty days, by which time germination is generally complete, the beds are watered with about four gallons per bed in the morning, and about two gallons in the evening. After about six weeks to three months the seedlings are about three to six inches in height. The seedlings are then pricked out into other beds two to three inches apart. At this stage the lower part of the root is bent upwards, and twisted round the upper portion, so that the depth of planting in the new beds is only about three or four inches. This unusual practice is considered to be of great importance, as it encourages the formation of a shallow bushy root system, instead of a long tap root, and this makes planting out easier and cheaper. These pricked out beds are also watered either by irrigation or by watering cans, but once a day is enough.

Hagari afforestation division.—The Balukhand method is used experimentally in some beds in the Hagari nursery near Bellary with some modifications. The prime object in Hagari is the raising of *Prosopis* and other species, but it holds out some promise for casuarina also; and therefore it is referred to here, though it has not yet got universal recognition. A suitable site near a source of water supply and near the planting site is chosen. The site is levelled, and pot tiles are arranged, each tile touching its neighbour, or in any convenient sized blocks. In Hagari, the broad end of the tile is down, and the narrow end up, which is the reverse of what is described for Balukhand. In Balukhand the average size of a 25×10 pots block is about nine feet in length and three feet six inches in width. Sufficient space is left between the blocks for working. The pots are filled with prepared earth, consisting of fine sand, and alluvium. Sand is then packed between and around the pots, leaving about half an inch of the pots projecting above the sand. Seedlings raised in these pots, can easily be removed from them with balls of earth, transported with these balls, arranged in bamboo baskets or broken mud watering pots with the roots towards the centre and stems radiating outwards and upwards, and planted with the balls of earth. Wet sand is placed over the roots to protect the seedlings in transit. The practical difficulties experienced at present in Bellary are that the sandy soil tends to fall off from the root system during transport, the initial cost of the pot tiles is high, the distance from the nursery to the planting site is such that the cost of transport is also rather high. But the method is receiving constant attention and is being improved, and economies effected.

General.—In all the above nurseries, there is danger of the seed before germination being carried away by red ants. It has been suggested that watering with a solution of copper sulphate may remedy this. There is also a proprietary preparation made in England called Ant Killer which has not been tried in India yet.

In some cases where the seedlings are backward in growth, manuring with powdered castor cake has been suggested. The preliminary penning of cattle or sheep, but not goats, helps proper development of the seedlings. But a caution against forcing seedlings by excessive manuring has already been sounded.

Formation of Plantations

Espacement.—Espacement has a direct bearing on the rotation and the yield. With an increased rotation, an increased espacement may be justified. If the area is felled earlier, the yield is bound to be poorer than if the espacement were shorter. With a big initial espacement, in non-sandy areas, desiccation and deterioration of the soil are to be feared. With a wide espacement there is also greater risk of branchwood being produced instead of stemwood. As branchwood is of lower value than stemwood, this would mean decreased profits from the plantation. Short espacement with short rotation producing comparatively immature wood with a lower calorific value will also mean similar financial loss, though private planters do not consider it seriously.

It would appear that about the middle of the last century the espacement in casuarina plantations on the Madras coast was 12 ft. by 12 ft. when raised purely for profit, and 15 ft. by 15 ft., when raised for forest purposes. It is not however clear whether the forest purposes meant afforestation without an eye to profit, but for the climatic benefits accruing from them. In Mysore casuarina appears to have been planted for many years at 15×15 ft. though it was subsequently changed to 9×9 ft., for cultural reasons, specially the suppression of scrub and grass, and the resultant fire protection. But these risks are absent in coastal sandy plantations. Troup considers that 9×9 ft. is the minimum satisfactory espacement for casuarina. In Nellore it has been worked out that 7×7 ft. is the proper espacement for a rotation of ten years, while 6×6 ft. espacement will suit a rotation of seven years. The espacement adopted in Mysore is 6×6 ft., and with this small espacement, though the rotation is ten years no thinning is prescribed. However latitude is given to the district forest officer to thin out suppressed, dead and dying stems to meet demand for fuel. In the Lower Godaveri division an espacement of 7×7 ft. is prescribed. In the Padugais of the South Salem division also the same espacement is prescribed. Mr. D. L. Sathe in an inspection note on the Nellore forests writes that considering all aspects of casuarina planting it would be safe to say that 7×7 ft. with thinning in the sixth year and final felling in the tenth year is the most suitable for our requirements of small wood and medium sized billets.

The generally approved espacement in South India at present is either six feet by six feet or seven feet by seven feet.

Size of Transplants.—With one note of difference, there is a consensus of opinion in favour of using large transplants. South Canara division favours one year old transplants over three feet in height, as they stand best the heavy monsoon, and establish themselves quickly and overtop the weeds. The average height of trees raised from such big transplants in Sarpanamane reserved forest after three growing seasons was found to be about twenty-five feet. In the plantations near Madanapalli in the Ananatpur division, it has been considered that seedlings should be about eighteen inches in height, healthy and not too whippy, to be fit for transplanting. In the Sriharikota plantations of the Nellore division, it is considered that a height of about two feet will be about the best for all practical purposes, though seedlings of any height from one to three feet are good enough for successful transplanting. In the Padugai plantations of the South Salem division, seedlings from eighteen to twenty-four inches in height are prescribed as most suitable for transplanting. In the Lower Godaveri division, some authorities favour small plants of 9 to 10 inches in height, while others are in favour of plants 12 to 18 inches in height. The Mysore forest officers consider transplants from 9 to 18 inches tall as best for transplanting. In general, it may therefore be said that the best average size for transplanting casuarina is about two feet.

Best Season for Transplanting.—The best season varies with the locality, and with the size and object of the plantation. Private planters with small plantations, can afford to depart from the best season, as small plantations can be artificially watered more easily than extensive plantations. Thus along the banks of the Cauvery private planters often put out their seedlings in December. About this time, they have some rains, and viewed from that stand-point, it is a satisfactory time. But the hot weather follows, and if the plants have to tide over the trying period considerable artificial watering, and other protection is essential. Private owners in Guntur are said to plant in September or October, and a day is chosen after heavy rains, when the ground is so moist that pressure with the foot makes moisture ooze under foot; and on such a day,

transplants smaller than normally used by the forest department are planted in crow bar holes, at an espacement of three feet by three feet by eye, without aligning and staking, in areas which for about three years previously have been under cultivation with food crops. Further these Guntur plantations are not watered. It would appear that the Guntur private technique is in every respect different from the scientific silvicultural methods of experienced forest officers.

Present opinion in the Padugais of the South Salem division is in favour of planting by the end of July, so that the plants may get not only the north east monsoon, but also the south west monsoon, at least off and on during the critical months following planting. Such early planting, gives greater opportunities for early replacement of casualties as they occur, and therefore of ensuring a better stocking in the first growing season, than can be done with later planting. Earlier planting also causes better development of the stem and deeper penetration of the root system, so that with established plants less watering in the second year and almost no watering in the third year may be done, thus resulting in economy in formation costs.

In the Lower Godaveri division, the north east monsoon is the main wet season. Though in one year the last week of August gave better results than earlier planting. Late planting in the Kandikuppa plantations has been observed to be unsatisfactory. It is therefore prescribed that the planting should be started as soon as there is sufficient rain to wet the sandy soil down to the sub-soil, and should be done on cloudy days when it is drizzling. It is here considered that casualties should not deter us from July planting, as casualties can be replaced at each spell of rain afterwards.

In the South Canara division, it is realised that success depends on timely planting, and a few days difference will make all the differences in the survivals and growth. Planting is done with the first burst of the monsoon, as the coolies are accustomed to work during the rains. Generally the best date is about the 5th or 6th of June, and is never later than the 15th of June. Due to the great regularity of the break of the monsoon, and the certainty of adequate rainfall, there is no difficulty in this district of the same magnitude as is met in drier districts.

In the Sriharikota plantations of the Nellore district, planting in July or August is prescribed in depressions which are likely to get waterlogged for short periods, so that plants may be fully established before the north east monsoon. But in other localities it is prescribed that planting should be completed by the end of September so that the north east monsoon may help to establish the plants. Early commencement of planting will help in getting the maximum possible area planted with the available labour every year, and give the plants time to establish themselves before the dry weather which begins in December. The initial benefit conferred on the root system of the plants may also economise in the watering in the second and third years, though more watering is required in the first year. Against this advantage is the risk of failure if there is total failure of the south west monsoon, and if the labour is insufficient to cope with the increased watering required to keep the plants alive till the north east monsoon.

In Mysore, transplanting has been generally done in September-October, but experiments have convinced them that better results will be obtained by planting in May-June provided one or two showers fall immediately after planting. If there is no rain at this time, they transplant with the very next rains. It is considered good to have rain within a week after planting, especially as no artificial watering is prescribed, and they have to be very careful to choose a proper time to ensure success from transplanting, in very first year. In every subsequent rain casualties are replaced till October.

Method of Transplanting

According to Troup, many of the plantations in North Canara have been raised from natural seedlings collected from around existing plantations in the month of November, and kept in nursery beds until the following June when they were planted out. But natural regeneration of casuarina is generally absent in other localities. Hence nursery raised seedlings are transplanted in all plantations in South India at present.

Pits.—Though it has been stated above that in Guntur private planters plant in crow bar holes, there is unanimity in all other localities on planting in pits. In sandy areas, regular cubical pits cannot be excavated, so suitable obconical depressions are scooped out. Where the soil is of firmer texture, one foot

cube pits are dug sufficiently in advance of the planting season, the dug earth weathered, and refilled into the pits, for receiving the transplants. Where the soil is saline or alkaline, the excavated earth may be rejected and the pits filled wifh sand or loam brought from outside, so that the young plant may be established until it is able to resist as far as possible adverse soil conditions. In the Mangalore division an experiment was done to compare the effect of two feet deep pits with one foot deep pits. After three years there is no appreciable difference in the height growth of trees raised in the two treatments.

Aligning and Staking.—Private planters are not particular about aligning, or espacement, everything being done by eye. But to facilitate tending operations, and to some extent to ensure uniformity of growth and maximum yields, departmental plantations are suitably aligned and staked before pitting, so that the pits may be regularly espaced. The technique of aligning and staking has been described already and is therefore not repeated here. It may be stated that as staking is said to attract white ants, their use is not permitted in Mysore. In the Madras departmental plantations, the stakes are used in addition to indicating the planting site, for supporting the transplants, till they are established, and can stand up by themselves.

Planting.—In Mysore while planting the seedlings, a small mound is raised close to and on the down hill side of the plant, with the object of conserving some of the rain water for the plant. The seedlings as already stated are not supported by stakes. Otherwise the planting procedure is normal, with this difference that the root system of the transplants have the bend produced by the peculiar procedure followed during pricking out, and the root system is comparatively shallow but bushy. Their success justifies the procedure.

In Sriharikota, Nellore division, two tall seedlings and a stake to support them are planted simultaneously with the watering and puddling of sand in the pits. Sand is then filled into the pit, and finally tamped to make the plants and the stake firm. Another cooly follows the planting cooly, and ties the plants to the stakes with *pandanus* leaf fibre. The method ensures that there is no root bend, that the stakes are firmly planted, that the plants are kept erect, that they are not shaken or uprooted by the wind, and even if there are fifty per cent casualties, at least one plant survives at each stake, ensuring if possible full stocking. The method has been so carefully devised, and the allotment of labour so carefully done, that the work proceeds with great efficiency, without the wastage of man-power.

Alignment, staking, pitting, planting, and tying the plants to the stakes are in vogue in all departmental plantations, with but little variations, so that there is no need to describe the procedure in the other plantations.

Mr. Jogiraju, in describing private plantation procedure in the Vizagapatam district, writes that in planting a seedling in loose soils its roots are held in the pit at the proper depth, sand thrown in from all sides, and heavily watered. In stiffer soils also this method is generally adopted, but sometimes the pit is filled with water, and the roots of the seedlings held in it while the pit is filled in with soil. The seedlings are observed to establish themselves better when planted in this manner, than when the plants are first planted in dry soil and then watered. Protection by hurdles, or other suitable screens are sometimes wanted against wind uprooting the plants or sand drift burying them. In saline soils the pits are often filled with sand or other loose earth to enable the plants to establish themselves easily. Every care is taken to establish the seedlings quickly and uniformly all over the area. All plants which establish themselves without the tips of the leading shoots withering, grow tall vigorously, while those whose tips wither away, branch out and become bushy, and it takes them some time before one of the branches begins to lead.

Watering

The objects of watering in a casuarina plantation, are to keep the newly planted transplants alive till their root system has developed sufficiently to absorb moisture from the soil, to accelerate their growing and to keep established plants alive during drought till their tap-roots reach a permanent source of moisture. These depend naturally on the size of the transplants used, the length and condition of the root system of these transplants, the care with which these transplants are extracted from the nursery, or the care with which they are transported to the planting site, the care with which they are planted so that the root

system goes straight down without being bent, broken or otherwise injured, the moisture and humidity conditions of soil and atmosphere at the time of planting, and the capacity of the soil to retain the moisture and yield it to the plant when required. With so many variables, no hard and fast rules can be laid down for the quantity, periodicity, and number of years, of watering. So the officer on the spot will use his discretion in controlling the watering judiciously during the first two or three years, with the object of getting a fully stocked plantation at least cost.

In Mysore no watering at all is prescribed, the technique depending on the retention by the soil of the atmospheric precipitation. The hardness of the subsoil, probably preventing loss of mositure by deep percolation, the ploughing of the soil to improve its absorptive and retentive capacity for moisture, and the season of planting just at the beginning of assured rains, are factors helping this techinque. However, help by artificial watering may still further improve growth, as it has been observed that an area of casuarina plantation formed behind the Mavathur tank in Kankanahalli taluk, which was irrigated, gave in one year trees 22 feet in height, against a normal height of 3 feet by the dry method. Carefully conducted plantations following the Mysore technique in North Salem division have however failed.

In private plantations, as in Guntur and in Vizagapatam, there is no particular prescription with regard to watering, and the planter uses his discretion constantly, and does from time to time what he considers necessary. In Vizagapatam, the plants are watered in the first year as and when necessary, but in general there is no second year watering. In some situations, it is said that plants have been established, and are growing moderately well with the help of rains alone, by thorough ploughing of the land before planting, (as in Mysore practice) and making lengthwise and crosswise bunds (as in the *Tummala* method of regeneration) so as to form shallow reservoirs each of about 10 cents which hold up, absorb and retain as much of the rain water as possible for the use of the plants planted in them. In the Guntur plantations, with a close espacement of 3×3 ft. there is such a wide margin for casualties, so that there is reasonable prospect of full stocking even if only one-fourth of the plants put in survive.

In the South Canara division, no watering at all is necessary, as the casuarina is transplanted at the commencement of the monsoon, and the assured annual heavy monsoon rains are fairly well distributed, ensuring success. So, no watering is prescribed for these plantations.

In the Lower Godaveri division, two waterholes are prescribed per acre. The transplants are copiously watered for the first few days after transplanting, if soil conditions need it. Thereafter the plants are watered during breaks in the rains, in the first hot weather after planting, and at other seasons in the first year if the plants appear to need water. The watering is done slowly and close to the stem so that the water may soak deep down, instead of spreading on the surface, and reaching only shallow depths. If the water spreads thus on the surface, superficial rooting may result and the plant will not develop a tap-root to tap the deeper layers of natural moisture. If plantnig is done with care, and watering is also judiciously done in the first year, it is considered that normally no watering will be required in the second year. But sometimes watering has to be continued during breaks in the rains of the second year also. Thereafter no watering is prescribed.

In the Nellore division (Sriharikota) wells are dug in the planting area at the rate of one well for every 1½ acres. These wells are really waterholes with sloping sides or little ponds of water. They are about thirty feet diameter at top narrowing down to ten feet, and even narrower, at bottom. The depth depends on the depth of the water table, and may be about 10 or 12 ft. The sides just above and below the water level are supported against collapsing by wattle or straw supports. Satisfactory inclined approaches are provided from water level to plantation level, so that the watering coolies may walk in, fill up their pots, and climb out. Transplants are watered twice daily for about ten days after planting, so that they may get established. From November to January they receive water on every non-rainy day. The total number of such days in a normal season may be about fifteen. In February and March the backward and wilting plants are watered once in three days. The number of plants which require such watering is estimated at about one-fourth of the total number of plants. From April to June the whole plantation is

watered once in three days. Every time the watering is done, each plant gets about half a gallon of water. In the second year watering is prescribed for only such plants as need it. In *practice* this has meant the watering of about half the plantation once in three days in February and March, and the whole plantation from April to June. In the third year the extent of watering is considerably less, only the most backward plants receiving watering. In general it has been observed that the first forty rows of plants, along the east require less water than plants in the western portion, and those on mounds. It should however be noted that with apparently the same water supply, casuarina plants on the excavated mounds round the wells put on better height than those planted on the normal level of the plantation.

Watering is the most costly operation in the establishment of these plantations. Mr. J. A. Master, in his inspection note on the forests of the Nellore division dated 25th April 1940, writes, that in an experiment by the district forest officer, seedlings planted on the 30th of November 1938 were watered both morning and evening for one week to make the sandy soil consolidate in pits. Then some plants were allotted to no watering treatment. Thereafter no watering was done for these plants. Though 1938-39 was a year of drought, the seedlings survived the hot weather. They did not put on as much height growth in the first year as the neighbouring plants which were watered from February to June 1939. On examination, the watered seedlings were found to develop surface roots, whereas the unwatered ones developed a long tap-root. After the rains in October and November 1939 the unwatered seedlings shot up to 4 to 6 feet in height and were taller than the neighbouring watered seedlings. There is thus a case, if not for entire non-watering, at least for further economy in watering.

In the Padugais of the South Salem division also, the water level is high, and wells can be sunk easily and cheaply. The number of wells and their sizes is left to the discretion of the district forest officer. He has however to consult the River Conservancy division of the engineering department so that the sinking of the wells may not affect the water supply available from the Cauvery. In the Padugai plantations, casuarina plants are being watered twice daily for seven days after planting, once daily for one month, every other day for the next month, and once in three days after that. Watering is continued during breaks in the rains of the second year if found necesary. The district forest officer is given the option of ordering more frequent watering if he considers it necessary, or of having less frequent watering if the water level is high due to floods in the river. In addition to watering, occasional soil aeration is also prescribed.

General.—The Bombay Annual Report for 1926-27 records that the result of reducing and even of abolishing the watering of casuarina plants during the first year in the plantations was watched during the dry season of 1926-27. The results in North Canara division, showed that the watering cannot be entirely dispensed with in ordinary situations, but that watering on alternate days gives excellent results, whilst watering at longer intervals resulted in numerous casualties. The Dehra Dun Research Report for 1927-28 records that the results obtained show that (1) the watering cannot be entirely dispensed with, (2) it can be considerably reduced and (3) the extent of reduction is dependent on soil conditions and depth of subsoil water level. Troup writes that excessive watering should be guarded against, as it is considered to be a contributory cause of fungus attack.

Mechanical pumps have been tried in Nellore division, and in the Padugais, but have not been continued. In India it often happens that mechanical devices cannot compete with the cheap manual labour, which does not go out of order, does not need repairs at the cost of the employer, and ordinarily is cheaper than machines. Mechanical methods may however solve extraordinary difficulties such as lack of labour, or where the labourer suffers by being constantly in saline water. In such cases the difficulties can be overcome by using pumps to raise the water from the well to suitably placed wooden or metal troughs at plantation level; from which manual labour may water individual plants.

Early Tending

Soil Aeration.—In sandy soils as in Sriharikota, no soil aeration is probably necessary. In the Padugai plantations, where the soil is more loamy than sandy, the soil round plants tends to cake after watering, due to the prevalent excessive heat. This soil cake has got to be broken up occasionally, especially

when the interval between successive waterings is extended. The agricultural dictum that conscious and untiring efforts with the hoe are often more remunerative in trying times of drought than the severe labour and serious expense incurred in watering any large extent of ground, should constantly be remembered. The soil working facilitates aeration of the soil round the roots, and by cutting off the water film below ground level prevents the upwards migration and evaporation of soil moisture, making it more available for the plants, than if no soil working was done.

Weeding.—The growth of weeds and climbers depends on locality and climate. In plantations raised on pure sea sand like those in Sriharikota in the Nellore division, there is generally no weed or climber growth requiring costly attention. In South Canara the weeding is done by the *kumridars* if the area is under *kumri* regeneration. Otherwise weeding is done departmentally. Two weedings, the first in August/September and the second in November/December, are prescribed. All growth to a diameter of four feet round the seedlings is cleared thus keeping the stems free. All decaying material is removed from the vicinity of the stems. Climbers are pulled out when the ground is sufficiently wet. The cut weeds are laid in rows along contours. If any borer attack is feared, scrapping is done round each stem to a radius of two feet round the plant during the second weeding. In the second year also, two weedings have been prescribed, one in August, and the other in November. All growth will be cleared to a radius of two feet round the stems. The district forest officer will decide whether any climber cutting is required in the third year. The weeding prescribed is weed cutting as in teak. It is however noticed that some regrowth like *Macaranga, Leea,* etc. is allowed to come in for soil protection.

In Mysore weed cutting is done in January, May and August following the year of plantation. Heavy weed growth may be removed in the second and third year also.

Pruning.—In the working plan for the Nellore division, the necessity for pruning is discussed. Free circulation of air is considered essential for the proper development of casuarina. Besides aeration, it is considered that the mositure laden sea breeze provides secondary moisture to the plants, especially during their infancy and in hot weather. In areas close to the sea where the growth is initially more rapid than in other parts the side branches interlace in the third year, and elsewhere in the fourth year. Pruning is therefore prescribed for these plantations in the third and fourth years, depending on the condition of the plants. Side branches are pruned up to a height of about nine feet. At the same time all dead and dying trees are extracted. In an inspection note of the Nellore division dated 17th September 1938, the conservator remarks that the working plan prescribes pruning in the fourth year, but in actual practice it was found that the backward plants could not stand pruning in the fourth year, and died as a result of pruning at that age. Hence pruning was modified to spread over two years, the more advanced plants being pruned in the fourth year, while the backward plants were pruned in the fifth year. Normally the pruned branches are not saleable; but under present extraordinary conditions they are sold as *Chulli* fuel, so that part of the cost of the pruning is met by sale of the pruned material.

In the South Canara division, no pruning has been prescribed, as it has been found that in private plantations the lower branches are shed naturally in the 3rd or 4th year after planting. But it is provided that if the district forest officer considers it necessary the lower branches up to a height of eighteen inches may be pruned during the first weeding.

In the Lower Godaveri division, it is prescribed that pruning may be done in the fourth year after planting by cutting with a sharp knife all side branches up to seven or eight feet above ground, preferably before summer, which allows free circulation of sea breeze, through the plantation. The management is however expected to keep in touch with modern practice in this respect, and carry out such improvements as may prove necessary.

In Mysore, side branches are pruned to the height a man can conveniently reach, in the fourth or fifth year. This height is estimated to be about seven or eight feet. The lowest whorl of branches nearest to the ground are however left, because the casuarina trees are expected to coppice and give a coppice crop for the next rotation, if they are left. It appears that behind the aircraft factory on the White Field Road, near Bangalore, they have such an area of casuarina coppice regeneration.

Replacement of Casualties.—In the South Canara division, it is considered that with timely first planting casualties will not be more than about five per cent. The whole planted area is gone over about the end of July or middle of August, and all casualties are replaced. In the South Salem division Padugais, casualties are replaced in the first year as they occur but never after January. In the Sriharikota plantations of the Nellore division, casualties are replaced in the first year immediately they are noticed, with specially strong and vigorous seedlings. Every endeavour is made to obtain full stocking in the first year. In all these plantations it is considered that casualty replacement in the second year or later is of little use. In Mysore casualties are replaced in the first year, up to October, taking advantage of every rain, whenever initial planting fails. In the second year also, ploughing is done in July-August, a second crop of horsegram is sown, and casualties replaced at the same time, and again in October if necessary. Casualty replacements are not done in the third year. In the private plantations in Guntur casualties are replaced in the first, second, and third years after planting, on suitable planting days during the north east monsoon, though with their three foot espacement such casualty replacements may not be necessary. After the third year, failures are accepted as such without further attempts at stocking.

Kumri or Taungya

Though it is not always possible to secure *kumridars*, and though field crops cannot ordinarily be raised in sandy tracts, the possibility of combining field crops with casuarina regeneration is always kept in view in the Madras province. In Mysore, wherever *kumridars* can be got, casuarina is raised with a field crop, generally of horsegram. As an encouragement to the *kumridars*, seeds of horsegram are sometimes supplied by the department to the *kumridars*. Horsegram is considered to enrich the soil, and to promote the growth of casuarina. Horsegram is usually sown in August-September, but it is considered that when some rains can be relied on in the south west monsoon, earlier sowing of gram may give better results. Inter-cultivation by *ryots* in the second year is also encouraged, the principal field crop again being horsegram. Castor has also been successfully cultivated with casuarina, but it is considered just to raise the casuarina in the middle of the strip, six feet apart in lines twelve feet apart, so that the castor plants may be as far away from the casuarina plants as it is possible to make it. Experiments by the Madras silviculturist, with teak as the forest species and castor as the field crop have shown that castor takes too much from the soil to the detriment of the forest crop. In Mysore ploughing and sowing horsegram is done in the third year also.

Plantation Costs

Any statement of present costs with the tremendous fluctuations in the labour market at present, is sure to be misleading. Before the war, the plantations were estimated to cost from about Rs. 15/- to Rs. 50/- per acre, according to the method adopted, the locality, the labour available, and several other considerations.

Thinnings

The necessity for, and degree of thinnings will depend on espacement, rotation, objects of management, market conditions, nature of the produce in demand, etc. Where some timber production in addition to the fuel supply are aimed at, moderately close planting, a long rotation, intermediate thinnings, are indicated. Where fuel production is the main or only aim, a moderate espacement, a reasonably short rotation, and no thinnings are indicated.

It was at one time held that since casuarina grows rapidly and is a strong light demander, regular thinnings were necessary for the proper development of the stems which otherwise tend towards undue height growth at the expense of volume production. With a planting at 6 × 6 ft. espacement, the first thinning was usually considered necessary after about four years, while with wider espacements the first thinning may have been at five or ten years according to circumstances. But modern forest officers consider that as casuarina is a strong light demander and is sensitive to suppression, close planting results not only in loss of height but also of girth, unless thinned very early. The natural habit of the tree is to grow straight and clean, even when planted at a wide espacement. Thinnings will not therefore be necessary if the original planting is at as wide an espacement as is compatible with the rotation adopted.

Further it has been observed in the Ponna plantations (Sriharikota range, Nellore division) that the yield in 1940-41 from an acre of unthinned plantation was seventy-three tons, against a yield of only forty-five tons from the portion thinned in 1936-37. Even on inclusion of yield from previous thinning, the gross yield was only fifty-two tons. Some earlier unthinned plantations had given eighty-three tons per acre. Thinnings have therefore been stopped from 1940 in the Sriharikota plantations, and where the object of management is the production of maximum quantity of fuel per acre, thinnings are considered unnecessary.

In the Lower Godaveri plantations, it has been prescribed that thinnings may be done in the sixth year, by removing all dead, dying and suppressed trees, and then a modified mechanical thinning along alternate diagonal lines be done, leaving a suitable tree standing in the thinned line to balance every blank space in the adjoining unthinned line. Mr. Sathe, in his inspection note, dated 1st June 1936, mentions a plot of one acre selected in the best portion of a fifteen-acre plantation ten years old, in the Lower Godavery division, which was heavily thinned leaving sixty trees standing. Fourteen out of the sixty standing trees had died out, and those that were surviving had put forth epicormic branches. Most of the trees were dead or dying and the crowns had not responded to the increased growing space. Large gaps had therefore resulted. Thinning to such a degree has therefore an adverse effect on casuarina. Again in another inspection note, dated 26-12-1938, Mr. Sathe writes that he has seen groups of casuarina dying in certain localities in the same division. The cause of their death, was mysterious, as there were no visible signs of borers or any other insect attack. The trees were just dying or becoming stag-headed. This seemed to happen after thinnings were carried out, and it was perhaps due to undue exposure of the standing stems.

In the South Canara division, thinning is left to the discretion of the district forest officer.

No thinnings have been prescribed for the casuarina plantations in the Padugais of the South Salem division.

In Mysore, no thinnings have been prescribed, but it has been left to the discretion of the D. F. O. to meet any demand for fuel, by thinning suppressed, dead and dying stems in plantations.

External Dangers

Animals.—As young casuarina plants are subject to browsing, and to being uprooted in sandy soil, or broken, by animals including domestic cattle, all casuarina plantations in Nellore and South Canara divisions are closed to grazing for a period of three years after formation. In the Lower Godavery division they are closed to grazing from the time of formation to the time of pruning. In the Padugais of South Salem division they are continually closed to grazing. For effective protection against grazing the areas are suitably fenced. In the South Canara division, though the plantations are protected against grazing, cutting of grass, and of leaves of all species other than casuarina for purposes of manure leaves is allowed, as it is in the best interests of the seedlings.

Insects.—Casuarina suffers from several insect pests. The seed is liable to be carried off from drying ground and from the storage pots by ants. Addition of a little camphor in the pot before tying up the mouth of the pot with cloth is sometimes effective. Another method recommended is to close the mouth of the pot with a cloth securely tied, and keeping the pot over the smoke from the ovens in kitchens, when they are to some extent safe from ants.

The seeds are again liable to be carried off by ants when sown in the nursery beds. A dusting of the seed bed with copper sulphate, watering with a solution of copper sulphate, or spreading ashes over the beds are said to have some protective effect. Raising seedlings by sowing seed in boxes or platforms protected from access to ants has also been suggested.

After germination, the seedlings have sometimes suffered from white ants. In one case watering the nursery with crude oil emulsion has been found efficacious. If to the crude oil emulsion, *Thevetia nerifolia* seed decoction as specified by the Madras agricultural college and research institute is added, its insecticidal value appears to be increased, and the protection improves correspondingly. It is suggested that care should be taken in the selection of the nursery site, so that there may be no risk from white ants. Copious irrigation is also said to minimise the evil.

Grass-hoppers and crickets, have been accused of cutting by day the very small plants in nursery beds, till the first needle like leaves are formed. As species of crickets like *Brachytrypes* and *Gryllotalpa*, which do damage to crops are said to differ from grass-hoppers, by their habit of living in burrows in the soil during the day, and only coming out to feed at night, it appears that only grass-hoppers are the offenders by day. These feed on young seedlings from morning to noon. In Mysore this attack is prevented or controlled by engaging a cooly to brush off the grass-hoppers from the beds from morning to noon. These insects do no damage to the nursery in the afternoon or at night. In a small experiment done over a nursery bed in the Emmanur research garden, half inch mesh wire netting was found to be sufficient protection against these insects.

Crickets, (*Brachytrypes achatinus* and *Brachitrypes portentosus*) are also reported to do serious damage to casuarina seedlings, even up to a height of about two feet. "The eggs are laid singly in burrows in the ground. The young crickets hatch out in about a month and become adults in six months. They remain hidden by day, and come out at night in search of food, which they carry to their burrows. By day they live in the holes, and feed on the needles collected at night." Hand picking and destruction of these crickets at night by lamp light may be one of the methods of control. To trace them to their burrows and get at them is the remedy suggested by Mr. V. S. Subrahmanya Ayyar in his "Further note on casuarina insect pests of Madras." Mr. D. S. Kaikini, range forest officer, Karwar, in the *Indian Forester* for October 1937, says that these crickets are very active during September, and clip off the leading shoots even at a height of about two feet from the ground, which is about the maximum height that they can jump up to. Planting tall plants four to four feet and a half in height, the erection of a thick close fence about four feet in height, and clearing a twenty yards belt of vegetation all round the casuarina plantation are methods suggested by Mr. Kaikini for the control of these insects.

A Hapalid *Phassus malabaricus* is in some places a serious enemy of casuarina trees. The caterpillar bores into the stem, close to the ground, and pupates in the larval burrow. The larva is said to inhabit the tunnel for nearly a year doing damage to the plant, and then the pupal stage extends over about three weeks in April. The tunnel may therefore extend up to about two feet in length. The moth merges about May or June. Trees suffering from the attack can be located from a distance by the yellow colour of the leaves. At close range, the callous formation at the point of entry, and the spongy domelike mat of small particles of wood and grass, are conspicuous. The control suggested by the Forest Entomologist is to locate the attacked plants, expose the entrance hole, and insert into the hole a blob of tar, on the end of a twig, so as effectively to plug it with tar. The larva succumbs to the contact of tar, when it tries to push its head or tail through the tar. The treatment has been observed to be effective, and plants treated in the early stages recover, and the wound is easily healed. Badly attacked plants require extraction, and burning. The attack does not seem to be serious in private plantations raised on sand, where there is no weed growth. This insect appears to be polyphagous in South India.

Bag worms are destructive of casuarina seedlings during the hot weather, though the damage is not yet serious. The caterpillar is said to live in underground burrows and to do the damage at night. Copious watering is said to minimise the incidence. Addition of a small quantity of crude oil emulsion to the water is also said to be efficacious. As the larval cases of bag worms are conspicuous, they may be picked out and burnt.

Mr. Jogiraju writes that a species of small black beetles, lurking during the day in large numbers in the soil at the base of the trees was found completely to defoliate in one or two nights, young trees in an avenue on the Krishnasagaram farm of the Vizianagaram estate in 1918. The damage done by these foliage eating insects is not however serious, as the trees soon put on fresh foliage.

He also writes that grown up seedlings in the nursery as well as young trees in the plantations are sometimes killed by the roots being bored into by the grub of a beetle (*Coelasterna scabrator* F. B.). The control suggested by Stebbing is the destruction of all trees seen to be attacked, by being cut and burnt, to prevent their serving as centres of infection for the rest of the plantation.

Recently some insect was observed to have bored through the terminal shoots of young casuarina trees in the North Coimbatore division. Complete pruning of the affected shoots and the destruction of these shoots was done under the orders of the district forest officer, Mr. J. A. Wilson. The operation effectively controlled the damage. The insect has not been identified.

Fire Protection

Though in places where there is little risk of fire, as in the Padugais, no special fire protection is prescribed, the protection being included in normal district protection, there is special provision for fire protection in other localities as in the South Canara division plantations, by a sufficiently wide cleared line all round the plantation.

Fungus

Casuarina trees sometimes die in groups, causing blanks, as a result of a disastrous fungs disease (*Trichosporium vesciculosum*) which often does great harm to plantations. The trees attacked first begin to wither, and after some attempts to throw up new shoots, finally die, and under the bark is found a black mass of spores. The disease is said to appear in dry as well as water-logged situations, and the exact predisposing causes are not known. Troup considers that the disease appears to be favoured by excessive watering and congestion; and suggests that thinning commenced early, and continued regularly, may check it to some extent. The fungus has however not been reported widely in recent years, and it appears that the attackes are not so widespread nowadays as in the earlier days of casuarina planting, though in some portions of the Nellore district (other than Sriharikota) it appears to have sometimes assumed serious proportions. In the Nellore working plans, it is prescribed that as a precautionary method all dead and dying trees in the plantation will be extracted as speedily as possible. The working up of the soil at the end of each rotation will to a certain extent minimise fungus attack. Troup also says that rest for two years between two consecutive generations of casuarina in Nellore is said to have good results in controlling the fungus attack.

On page 217 of No. 4 of Vol. 6 of *Forestry Abstracts*, it is stated that according to S. R. Bose, a fungus of weak virulence (believed to be a member of the ascomycetes group) has been found living intracellularly in the cells of roots, stems, green branchlets, funits, and seed coats of normal and healthy casuarina plants. A close connection has been observed between hyphal occurrence and the presence of tannin. Experiments on the germination of casuarina seeds in the presence of the fungus in pure culture are said to be in progress. There are no results yet reported.

Yield

This is a very varying factor, varying with the locality, the espacement, the rotation, the treatment, the method of management, etc. No useful purpose can be served by copying out various yield tables here, as the yield is conditioned by such factors. In general it may be said that the yield is regulated in working plans by an area control, and the yield per acre may vary from 25 to about 80 tons, with a rotation of seven to ten years, and an espacement of 6 to 7 feet. Further, as this is merely a note on casuarina plantation technique in the Madras Province, the discussion on yields does not arise.

NOTICE

A short history of the Assam Forest Service 1850—1945, by H.P. Smith, B.A. (Cantab.), B.A. (Oxon.), C.I.E., I.F.S., and C. Purkayastha, B.A., I.F.S. (Diploma), is available for sale by the Conservator of Forests, Assam, Shillong P. O., at a price of Rs. 2-4-0 per copy in addition to V.P.P. charges.

HOW TO GIVE TALKS ON FOREST SUBJECTS

For the guidance of the range forest officer

BY H. J. C. MILLETT, I.F.S.

Late of the Army Education Corps

(With apologies to the Army Education Corps for infringement of copyright as regards their technique!)

At the outset, abolish the word "lecture" from your mind. The old fashioned type of "lecture" will be worse than useless to your audience (unless it happens to be gathering of your own profession, in which case the question arises—are you competent to deliver a lecture?). If you want to give a *lecture* on some forest subject, give it to the Editor of the *Indian Forester* to pad out the pages of that technical journal. What you are going to give your audience of nit-wits is a TALK conducted on the discussion group method, which they will understand, which will keep them awake, and by which they co-operate in their own education. *An old-fashioned "lecture" will do none of these things.* Any one of you is competent to do it in this recommended way. Your object as the discussion group leader is not to display your own vast total sum of knowledge, but to impart just a *little* of it to your audience.

THE AUDIENCE

Ascertain the likely number of your audience, and make preliminary arrangements for the session accordingly. If the audience is a large one, *i.e.*, more than 20 persons, you will (unfortunately) be obliged to have them seated facing a stage or rostrum in the old fashioned way. But the *ideal* audience for instruction by discussion, is anything from 10 to 20 persons, and in this case you should set their chairs out in a semi-circle or even a ring if necessary. A semi-circle two or three deep, facing a blackboard, is your best arrangement.

VISUAL AIDS

You must have some visual aids, and the more the better. Visual aids include :

(*a*) background of displayed posters, pictures, photographs, graphs, diagrams, specimens—anything of that nature, dealing even if only remotely with your subject.

(*b*) Blackboard, with chalk (including coloured chalks if possible) and duster. The more use you make of the blackboard for tabulating facts, drawing diagrams, funny pictures, etc., as you proceed—the better. But remember this :—*DO NOT TALK TO* (*i.e.*, towards) *THE BLACKBOARD.*

TECHNIQUE

Start by telling your group (or audience) that you have come to give them a talk on (whatever-it-is,) but that THEY are going to do most of the talking. (This is not strictly true, but they like to hear it).

Inform them further, that you propose to devote two-thirds of the available time (say 20 minutes) to discussion, and the remaining one-third (say, ten minutes), to answering any questions.

Now, get them going, by throwing out *leading questions.*

(For instance, any forest topic could be introduced on the following lines :—)

Leader (Yourself) :—

"You all know what uses we can put trees to. They supply us with timber for building houses and carts and with firewood for cooking our food. They even supply leaves for your *bidis*—that is for those depraved few who, at your tender age, may have started smoking* —and for those even more depraved, toddy quite contrary to Government policy—*"

"..But all these are uses that we put trees to. But the tree does not grow just for your sake, or mine, or for Government's. *Now what would you say is NATURE'S PURPOSE in providing trees?*".

Those words *in italics* above, represent your first *leading question.*

After a long silence (do not allow it to become long), some nit-wit will provide a more or less fatuous answer. Suppose he says "For birds to roost on." This will be an introduction good enough to enable you to lead further questions towards that parti-

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**N.B.*—Insert all the jokes you can, into the whole session, but particularly at the commencement, to promote intimacy with your audience, to secure and maintain their interest and good humour.

cular topic you intend to lead up to. If your topic should be re-afforestation, you already have an excellent start. Describe how the *natural* regeneration of innumerable species of trees depends upon birds. If your topic should be anti-erosion, you can say—

"Excellent! You don't find birds in deserts, do you, because there are no trees? Have you—(turning to another person,)—ever seen in a desert? No? Oh, but you *have*, even if only quite small ones! You can find one everywhere on the outskirts of every town or large village in India, where people are for ever taking firewood, with or without permission, much faster than it can grow. Tell me now, *What happens to ground when trees are all removed faster than they can grow?*"

(Leading Question No. 2, and you are well on your way towards expounding your subject BY MAKING THE AUDIENCE THINK FOR THEMSELVES. Do it the old fashioned way by giving them a dreary lecture—worst of all if it is just read out—in which they play no active part, and the result you will find is that the less polite members of your audience will unashamedly go to sleep, while even the minds of the most polite will be occupied with other thoughts; and if anyone afterwards should ask of them if they had learned a single thing, they would have to confess "No.")

As you establish each point, write it up on the blackboard. This will assist you in SUMMING UP your talk at the end of the discussion period. *Do not forget to include a concise SUMMARY at the end,* of the various points established and their logical conclusion, *i.e.,* "So we are agreed then, that nature provides trees to attract as well as to conserve rainfall." (Questions—Where do you get the most rainfall? In the Sind desert? No. In dense, lush, forested regions? Yes. How deep would you expect to have to dig for water in a treeless desert? But you would not have to dig so far, in a dense forest?) —And we are agreed too, that trees grip the surface soil and by their roots prevent monsoon rains from gradually washing it all away from hillsides until nothing but the barren rock remains?" etc., etc.

General Notes

The *only* difficulty with this method of instruction, is to curtail to the utmost extent possible, the amount of information given at first hand by the group leader: and to expand to the utmost extent possible, the amount of information to be dragged out (at second-hand so to speak) from the audience themselves. DO NOT PERMIT ONE OR TWO CLEVER PERSONS IN THE AUDIENCE TO MONOPOLISE THE CONVERSATION. Toss the ball of conversation backwards and forwards among them all. Do *not* answer every question put to you, yourself, but instead, turn to some other member of the audience (group) and say "WELL WHAT DO *YOU* THINK? WHAT WOULD *YOU* SAY, to *THAT?*" Avoid the utmost, the use of technical terms, words that all (or most) of the audience would not understand,—such as "silviculture", "deciduous trees." Words such as "regeneration", "erosion", cannot be altogether avoided, therefore, when first you utter such words, slip in a clear explanation of what the word *means*.

In general, leading questions must go from you to the group, and the group sends an answer back to you, which you immediately throw back in a further advance from you to the group again for reply to you. Remember that *you* are the group leader, and therefore at the first sign of any conversation or argument arising between group members themselves, chip in immediately with something bearing upon the point and then divert the matter to some *different* person for reference or remark. If you fail to do this, the inter-group argument may become prolonged and develop along some side-line or side issue, leaving you ignored and helpless as a mere spectator and threatening to spoil the continuity of your instructional Talk.

INDIAN TIMBERS IN WAR

By R. Maclagan Gorrie, D.Sc.

(Conservator of Forests, Soil Conservation Circle, Punjab)

I. General position of the industry before the war

The use of structural timber in large sections had decreased considerably during the 1930s as a result of the increasing use of reinforced concrete. On the other hand the quantity of timber used for smaller articles such as furniture, tool handles, ploughs, yokes, carts etc., had increased appreciably and other uses for wood in smaller than structural sizes were also being developed. Up-to-date plant for plywood was scarce and the infant plywood industry was handicapped by the vested interests which preferred imported plywood. Manufacture of woodware articles such as furniture, tool handles etc., was such an intrinsic part of peace-time village life that it is difficult to produce any accurate data to indicate the extent of wood using village industries. One can safely say that there was very little capital invested but that the industry employed a very large number of people both whole-time and part-time working either in their homes or in small turnery shops. There was practically no organised industry in the larger towns and the trade demands for packing cases for soap, chemicals, footware, etc., were only met by long distance purchases, the general trend being from the Punjab towards Bombay and Calcutta. Apart from the use of imported tea chests most of the packing demands were thus being met by the internal market.

II. War-time demands and production

At the outbreak of war there were 3 obvious sub-divisions of the timber industry, each of which had its own local organisations, but none of them except the army's technical equipment was handled by any centralised agency. The 3 main classes were as follows :—

(*a*) *Structural timber and railway sleepers.* The combined requirements of the army and the railway were handled by the Joint Timber Advisory Officer who worked with both Army Headquarters and the Railway Board. The railways had a sleeper pool arranged on a regional basis so that groups of railways did their own purchasing, usually from the Forest Department or from forest contractors. The railway also had two sleeper creosoting plants in the Punjab and Assam, the object of which was to impregnate large quantities of soft wood sleepers which could only be used after chemical treatment had been applied.

(*b*) *Fashioned material for what is usually covered by the term "General Stores".*

This includes a vast and heterogeneous collection of items such as packing cases, packing crates, furniture of all sorts including barrack-room fittings, tool handle and helves, bamboo articles including tent poles and bamboo woven matting, barrels and casks, straw-board and other material for cartons and light containers, baskets for earth moving, packing of fruit, etc. The army's requirements of these items had up to that time required no special organisation but the standards of acceptance for army purchases were usually fixed by the General Stores Inspectorate at Cawnpore and by the local Garrison Engineers where furniture was their responsibility.

(*c*) *Technical equipment.* The main civilian items coming under this head are :—shuttles for spinning, bobbins, reels, spindles; battery separators; materials for paper making including grass, bamboo and paper pulp; plywood; bridging and construction material; poles for telegraphs, telephones and electric transmission. The technical equipment used by the army and containing wooden components was quite varied when the war broke out, but the subsequent development has demanded such very diverse artillery and signals equipment that could only be covered by a gradual expansion of the various technical inspectorates under the M.G.O. The main purpose of this paper is to give some details of how these demands have been met in India.

III. Sources, markets and centres of production

The distribution of forests in India is so very irregular as to constitute a serious problem for woodware demands. For instance, Assam and Burma have 80 per cent. and 60 per cent. of their total land area under forests, whereas in the dry western half of India the percentage of forests drops to 5 per cent for the Punjab

and 3 per cent. for the North West Frontier Province. Even these small percentages are mostly in the high hills where felling and conversion of the standing trees and extraction to distant markets on the plains presents many difficult problems. Many areas on the other hand are so short of wood of any sort that cow-dung is burnt extensively as fuel. In such places building timber is obviously at a premium and even the villager uses imported wood if he can afford it, or else goes without. In the damper areas where forests grow more freely this difficulty does not arise, and wood and bamboo are available for almost every need, the bamboo providing material for almost every common requirement. The areas of the greatest forest wealth such as the Malabar coast and the Assam valley are apt to concentrate on their best timbers, neglecting the poorer ones entirely. In a number of places a good tradition for the making of furniture has been built up with local skill in carpentry and a good local supply of superior timber. Two examples of this are the use of *shisham* (*Dalbergia sissoo*) at Kartarpur in the Punjab and Bareilly in the United Provinces, and the use of rosewood (*Dalbergia latifolia*) in Mysore and Cochin, walnut carving in Kashmir and the making of toys and dolls in Madura.

IV. Peace-time ordnance production

A Jap radio commentary early in the war published a wise-crack about the Gun Carriage Factory at Jubbulpore to the effect that it made everything except gun carriages! There was a considerable amount of truth in this statement for both the Gun Carriage Factory at Jubbulpore and the Harness and Saddlery Factory at Cawnpore handled a very wide variety of technical equipment to meet the army's peace-time requirements. There was very little opportunity for mass production as individual stores were usually asked for in very small quantities. The standard of skill in these two institutions was, however, of a very high order and the quality of the work was quite in a class by itself. As the war-time demands gradually increased both as regards quantities and the variety of equipment these factories were unable to compete with the indents and work had gradually to be delegated to outside trade organisations.

My own humble share in these war-time activities started with a spell in the Gun Carriage Factory where from November 1939, onwards we built up a timber inspection section to cope with the factory output and toured the other Ordnance factories and Arsenals to help them with their wood problem. Later as Timber Adviser of the Master General of the Ordnance, I had my base in General Headquarters, but toured even more extensively to establish a standard of inspection for accepting trade deliveries of wooden articles wherever we could get them made in the Punjab, the Central Provinces, the Malabar coast, Bihar, Assam and Calcutta. As a third phase from May 1943 onwards I became Director, Woodware in the Director General of Supplies' organisation.

V. Early war-time efforts at increased production

The absence of good saw milling machinery was early felt and many proposals for increased production foundered on this crucial point. The Punjab, however, produced a bandsaw unit manufactured in Sialkot by the Clyde Engineering Coy. and these small bandsaws were gradually installed in a great many places, either by enterprising contractors or by the Timber Supply Directorate which was organised in the summer of 1940 under Mr. L. Mason (later Sir Lawrence) and Messrs. W. E. Flewett and D. Stewart. The question of power for driving these mills was comparatively simple as the Sialkot bandsaws could be driven singly by small detached electric motors of 3—5 horse-power, or driven in multiple by heavier steam units. These Sialkot bandsaws rapidly came into regular use and were undoubtedly the means of maintaining the ever-increasing demands for timber which by the end of 1940 were reaching very large figures.

VI. Lack of facilities for seasoning

In the manufacture of woodware articles the main consideration is the proper seasoning of the wood. India has suffered through not having any established trade custom, such as exists in other countries, that timber when purchased on the market should be seasoned. If you wish to make a box or a table in Britain or America you buy seasoned timber from a timber merchant. In India you cannot do this, and there is no possibility of obtaining any guarantee that what you buy has been seasoned. The Forest Research Institute at Dehra Dun has done much good

work in helping a number of private firms and Government institutions to set up their own seasoning kilns, chiefly in Calcutta area. Speaking broadly however the use of kilns is in its infancy in India and until the value of seasoned timber is appreciated and a preferential price is allowed on seasoned as opposed to unseasoned timber, the position is not likely to improve. Much of the criticism levelled at Indian woodware which was produced to meet war-time demands is due to the fact that unseasoned timber was used. The fact that Burma teak has always dominated the Indian market and is the only wood which can be used unseasoned with impunity has prevented a proper appreciation of the need for seasoning all others. This difference of course, is due to the fact that Burma teak is ringed and left standing for some years so that the logs are almost completely seasoned before they reach the market, whereas teak from Indian forests is brought on the market within a few weeks of the live tree being felled. There is no intrinsic difference in the quality of the wood, and botanically Burman and Indian teak are identical.

The subject of seasoning formed one of the many bones of contention between the Ordnance Inspection staff and the Department of Sulppy, whose duty it was to make perchases of manufactured woodware from the trade. Much pressure was brought to bear with the object of persuading the Department of Supply to pay a preferential rate wherever a guarantee of seasoning could be obtained from the supplier, but this was never agreed to and purchases continued throughout the war to be made in the cheapest market, and thus a golden opportunity was lost for introducing into India a standard of seasoning. The amount of shrinkage which takes place in a plank of any timber including teak during drying may be as much as 15 per sent. of its width and this occurs during the process of drying out. It can readily be seen therefore that warping and cracking of such things as nailed boxes or tenoned joints is bound to occur if manufacture is done in the green state.

VII. Constant changes in war demands

Enormous increase in production was brought about through the distribution of war-time demands for packing cases, helves, tool handles, *charpoys*, hospital furniture, tool chests, skids, levers, handspikes and similar military stores. During the course of the war, the type of articles asked for altered radically. For instance, early demands were largely for collapsible furniture to be shipped to the Mid-East, but subsequent demands concentrated upon packing cases and tent poles as being the major single items. The production during 1940-42 was concentrated in the Punjab, as this province showed far more initiative than the rest of India in taking up these new demands. Subsequently, however, with the difficulty of transporting the manufactured article and the shifting of delivery points to the south and east of India to meet the Jap invasion threat, the Punjab met a slump and many individual firms moved out of the Punjab in their attempts to follow up the trend of trade. The Punjab met the early war-time demands largely through the Punjabis' faculty for improvising simple machinery, such as lathes and sawmill benches. Another notable example of clever improvisation of machinery was seen in the Sunderdas Sawmill in Bombay, where the owner, Mr. Purushotamdas, built up a wonderful effort in mass production of ammunition boxes. This factory in peace-time had concentrated on light furniture, but proved of enormous value by switching over to war-time production. Apart from this single factory, Bombay was found to be singularly deficient in sawmilling and woodworking capacity when Burma fell, because previously the Burma teak traders had spoon-fed it with partly or wholly manufactured material. Insistence upon a high standard of workmanship by the Ordnance Inspection Staff under the Controller General of Inspection, Brig. R. D. T. Woolfe, did much to get a good standard of skill amongst workmen.

The training up of skilled labour was one of the chief difficulties in expanding the woodware industry as the only centres providing any good training were a few of the provincial handicraft schools, *e.g.*, Robertson College at Jubbulpore and the U.P. and Punjab Government Woodworking Institutes at Dehra Dun, Bareilly and Jullundur. The only other source of trained workers was in the Ordnance factories. The Harness and Saddlery Factory, Cawnpore, and the Gun Carriage Factory, Jubbulpore, have done notable work in turning out trainees from their woodworking shops. Most manufactured woodware, such as hospital

furniture, was obtained by the Department of Supply partly on a contract basis with firms known to be capable of doing the work, and partly new firms whose capacity was first ascertained. In the case of simple articles lending themselves to cottage industry manufacture, for instance tool handles and cane baskets, orders were distributed into country districts through local organisations under the Controllers of Supplies working in close conjunction with Director of Industries. The best example of this type of co-operation was seen in Bengal where the energetic Director of Industries took up different articles from time to time and developed rapid production to meet immediate demands. Actual timber requirements to be made up into woodware were usually met by the traders making their own arrangements, but as the war went on and good timber became scarcer and dearer, the tendency was for Government to issue suitable timber at controlled rates from one or other of the Forest Department depots. The difference between Government controlled-price and the free market price was considerable, so that the concession of drawing timber at the controlled price was much sought after. The output of manufactured woodware increased many-fold as the result of direct war requirements and the indirect demands caused by additional housing and office accommodation. The biggest single peace-time user of timber is the Railways and their demands for sleepers fluctuated, first through enforced economy, but later through the essential needs for replacement of sleepers in the track. The competition of war demands with that of railway sleepers was co-ordinated with those of war requirements, but other civil consumption had to take second place to war demands, particularly in those areas of the country where much of the available tree growth on village lands and in avenues was being sacrificed to meet the urgent demand for fuel.

VIII. Lorry bodies

The manufacture of wooden bodies in India had to be taken up as soon as a supply of imported chassis became available early in 1940. From then on, as imports increased in number this lorry-body building became a highly specialized trade in several different centres, notably in Bombay where General Motors Co. built up a large organisation to guarantee mass production and in 1943 reached a peak of nearly 3,000 bodies a month. Other firms in Madras, Bombay, Calcutta, Delhi and Lahore also took up this work.

Many interesting illustrations could be quoted of the difficulties which arise in such work as these generally centred round the vital questions of the choice of species of timber, seasoning, and the quality to be expected in the finished job. Pre-war experience was restricted to the use of deodar in Rawalpindi Arsenal, but an insistence upon deodar being used in Bombay led to much trouble, because of the fact that deodar was almost unknown in Bombay. A series of smashes quickly revealed that certain woods are treacherous and the Bombay manufacturers blamed the authorities' insistence upon the use of deodar. In the end the choice of southern Indian woods had to be allowed such as *poon* (*calophyllum elatum*) and *bijasal* (*Pterocarpus marsupium*) *aini*, (*Artocarpus hirsuta*), all of which gave good service. Smashed bodies frequently also revealed that unauthorized timbers were being used and bad collapses of planking were traced to a reddish wood *Hardwickia pinnata* locally known as *piney* or "*Malabar Mahogany*" (a typical example of the very misleading trade names under which timber is often sold). In lorry body building there are two very different requirements to be met, insofar as the runners or bolsters which serve as a bed for the lorry bottom and act more or less as the joists of a floor, have to be of immensely strong wood, whereas the planks for the body itself must be reasonably light and resilient. We thus had to separate these two requirements in the specification. The main timbers used for the runners were *sissoo*, rosewood, *padauk* and *bijasal* and to a less extent teak, *sal*, *aini* and *dhaman*. For the flanks a very much larger choice was allowed but deodar continued to be the first choice in view of its springy qualities. Some notable failures in teak lorry bodies were eventually traced to the use of logs which had lain felled in a Central Provinces forest for many years before being brought in and sawn up.

IX. Horsedrawn wagons

Early in 1940 a very large order for G. S. wagons was placed in India for delivery in the Middle East. The limiting factor in planning this order was found to be the manufacture of wheels. The wheel wrights' trade

is a very specialized business and a survey showed that the Gun Carriage Factory, Jubbulpore, was the only place in India capable of making a serviceable wheel. Trade attempts at producing samples showed how completely ignorant the average woodware manufacturer is of the technique involved in building a wheel. Many alternatives including metal castings were considered as it would have strained the Gun Carriage Factory's capacity to the utmost to produce the required number. Eventually the attempt to manufacture this order in India was cancelled, but not on account of this difficulty.

X. Tool handles

We started the war with one specification for all types of tool handles and including 4 species of timber. One, *yon*, was available in the Andamans, and another, *kau* or wild olive, was available only from N.W.F.P., thus leaving only two *dhaman* and *sal* which were readily available for Indian manufacture. Actually *sal* proved to be a heavy and intractable timber for this purpose and eventually its use for tool handles was given up as it was found to be treacherous when used in the very small cross-sections necessary for felling axe and sledge hammer handles. As the war progressed and demands increased both in quantity and in the variety of stores new woods were added to the specification from time to time. To govern our choice we fortunately had the data of timber testing carried out by the Forest Research Institute over many years previously and giving data on the stiffness, strength, shock resisting ability, retention of shape, shear, and hardness, as well as weight for nearly 300 Indian species. These data were of the utmost value but of course had to be followed up by practical tests of such of them as were found to be available in those parts of India where a tool manufacture could be established. In the end instead of one specification we finished with five, the top class being those handles requiring the greatest strength and resilience for which a dozen timbers were specified, the lowest class being for small turnery jobs such as screw driver handles for which some 60 were specified.

One interesting fact which this investigation revealed was the immense strength of the axle-wood group, botanically *Anogeissus*. The Burmese *yon*. (*Anogeissus acuminata*) was unfortunately only found in India in parts of Bihar and Orissa but full advantage was taken of this supply. *Kardahi* (*Anogeissus pendula*) of the C.P. and Jhansi was also in the same class and in fact was proved by the Forest Research Institute test to be probably the toughest and strongest wood in the world, but unfortunately it is only available in very small mis-shapen logs. In spite of its strength therefore this timber was not welcomed by the Gun Carriage Factory which clung tenaciously to the use of *sal* and *dhaman*, and it was some time before they could be stopped from using *sal* for handles. *Dhaman* proved to be a better choice but the kiln-seasoning of half-wroughts appreciably reduced the elasticity of this timber and led to considerable rejections from amongst G. C. F. production.

At a later stage in the war when the quantity of handles required far surpassed the capacity of the Gun Carriage Factory, price became a subject for feud between the Inspectorate and the purchasing organisation. It was pointed out many times to the latter that a shovel handle or an entrenching tool handle had to be sufficiently strong to enable a man to dig himself a trench when under fire. But in order to maintain this standard it was necessary to pay 1/4/- or 1/8/- instead of -/7/- or -/8/- which was all that the financial pundits in control of the purchase organisation were prepared to pay. Many of our men's graves in the African desert and in Burma swamps bear testimony to this passion for purchasing in the cheapest market.

XI. Packing Cases and Containers

In the early part of the war the supply of packing cases was sufficient to meet requirements and followed closely the pre-war standard laid down by the General Stores Inspectorate. For the special items such as munition boxes and rifle chests the Master General of the Ordnances' technical inspectorates' high prewar standard was fully maintained until the beginning of 1942. As the war progressed however and the quantity of the goods shipped abroad to the Middle East and to Paiforce continued to expand, great difficulties arose in providing the raw timber. Here again the question of seasoning proved to be of vital importance because many stores which appeared to be effectively boxed before being shipped, disintegrated on the quayside when unloaded a few weeks later. The first serious failure of this sort occurred, in the box called

the "Abadan Shook" which was exported to Iran for the packing of petrol tins. In spite of an elaborate specification governing this, vast quantities of planks accepted in India for these shooks proved in the end to be useless and had to be scrapped.

Other failures of stores packed in containers according to Ordnance specification occasionally gave trouble as in the case of a ply-wood boot box, and a soap box containing 50 bars of soap, but on the whole the departmental packing by Ordnance units stood up very well to these severe tests. Far more trouble was experienced in the private supply laid on by the manufacturing firms themselves. Notable examples of failures in this class were boxes for pith hats, canvas shoes, hospital slippers, putty, grindery for boots despatched from Australia, bath-bricks, and nails packed in light kegs in Calcutta. As supplies of the better timbers normally used for packing cases became more difficult and the more expensive, other cheaper and softer species became popular. In this way mango, *simul* (*Bombax malabaricum*) and Himalayan fir had to be accepted along with a formidable list of other less common soft-woods.

In the search for suitable alternatives *salai* (*Boswellia serrata*) which is one of the commonest trees in the dry Central Indian forests was tested and found to be adequate, but its adoption met with considerable resistance among many forest officers who considered it to be unsuitable even for packing cases. In the end however the advocacy of this timber proved to be correct as it stood up exceedingly well, even for the better classes of packing such as ammunition boxes.

The strength of any box depends upon the nails quite as much as on the strength of the timber, and increasing difficulty in the nail supply led to the examination of many substitute forms of packing. The use of a bamboo nail instead of a metal one was demonstrated but its use was never popularised as it required very different technique, including the preboring of every hole and the use of something like a large pencil sharpener to produce a point on the half-wrought nail. Cheap ply-wood, single sheets of veneer, bamboo matting, coconut fibre and many other substitutes for wooden packing cases were tried, and the resources of the Forest Research Institute at Dehra Dun for testing and experimenting on them were constantly used, their giant packing test cylinder which simulates a steevedores handling of a package proving particularly valuable.

The largest single unit for manufacturing packing case shooks to Ordnance specification was that of R. B. Devi Chand Khanna in Ravi Park, Lahore, in a factory which he ran in conjunction with the Punjab Forest Department's sawmills. These latter actually had 40 bandsaws and were at their peak producing 7,000 tons of hutting timber a month.

XII. Rifle Furniture

The several parts of a rifle which have to be made in wood require a very exacting standard for the timber. The chief feature is that there must be no alteration by shrinkage or distortion under the heat which is produced by rapid firing and must have good compression and shearing strength to resist recoil. It must be easily machined but strong enough to withstand severe mishandling. By long usage walnut was proved to be the most suitable wood but the Indian supply was entirely from Kashmir and heavy war-time demands were very difficult to meet. Prolonged tests were carried out on several likely alternatives and nearly a dozen species, mostly from Assam were passed as acceptable, although in actual practice only one alternative species, namely Himalayan maple (*Acer pictum*) was brought into regular use. The Himalayan maple occurs as single trees widely scattered in forests and village lands, as also does the walnut, but in spite of this difficulty very large quantities were produced and it proved to be equally as good as walnut in every respect. The sources of supply for the maple included some of the Eastern Punjab forest divisions such as Kulu and Seraj as well as Kashmir State and the Hazara district of the Frontier Province.

XIII. Saddlery

In addition to the standard cavalry fashion saddles for troopers and officers there are several other types still in use in the army for such work as horse ambulances, pack and draught for artillery, and another carrying a drum of signalling cable. Cutting of the wooden part which forms the panel is a difficult matter as most of these types require a scallopped or twisted design. Early in the war very large quantities of saddlery were

made and despatched to Rumania. Most of the half-wroughts were cut in the Gun Carriage Factory from *sissoo* amd were sent to the Harness and Saddlery Factory for completion. The cutting of these half-wroughts required the very highest quality of timber and logs of a very big girth, so that latterly this supply was very difficult to meet.

XIV. Ambulance Stretchers

The design for the wooden side pole provides for a small cross-section of an odd shape, which does not provide the maximum of strength in tension, so that breakages in the course of testing were often heavy. Many of the firms who took up stretcher contracts tried to avoid any form of stage testing either by the Inspectorate staff or by themselves. The amount of loss involved in salvaging the elements of fully assembled stretcher which broke in final test was of course serious, but the obvious improvement provided by a stage test to eliminate the poor material before assembly was seldom appreciated.

XV. Artillery stores

Apart from the gun and ammunition boxes already noted on, artillery equipment probably accounts for the most diverse and difficult items of any branch of the service. Timber poles and drivers' seats both at different times cost the Gun Carriage Factory considerable trouble owing to brashy timber failing in test, the timber being *sal* in the case of the poles, and teak in the case of drivers' seats. Other items of artillery equipment which gave scope for the use of little-known Indian timbers were the skids required for jacking up and mounting heavy coastal guns and the shear spars required for moving them. Skids are usually bound with a metal strap but the corrosion of metal on certain parts of the Indian coast is so severe as to make these stores unserviceable in a surprisingly short period. The tapered spar used for bridging is comparatively easy to make from a straight grown pole, but for the 30 ft. or 40 ft. spar with a hexagon cross-section without any taper, a very high quality of log was required and preparation of these long spars was exceedingly wasteful in timber. Levers and handspikes were another source of trouble in testing owing to the difficulty in applying any reasonable test other than brute-force.

The variety of ammunition boxes was legion, for not only does every type of shell, bomb, cartridge and fuze have its own peculiar type of box for field service but in going to and from various factories for shaping, filling and fuzing each has a special packing requirement at each stage of manufacture. The Small Arms Ammunition Factory at Kirkee made their own boxes for packing most of the ammunition they made.

XVI. Pontoon and Bridging stores

Before the advent of heavy metal bridges the standard equipment known as the Folding Boat Equipment was much in demand, and great efforts were made to produce the folding boats themselves and the accompanying road-bearers and chesses. The specification for the folding boats was English but the substitution of Indian *sissoo* for ash and *deodar* for European deal produced a very serviceable article. Unfortunately all Indian timbers of high strength are heavier than the corresponding Eurpoean ones, so that the boat itself and its superstructure were both over-weight. Many of the folding boats imported from Australia gave way under tropical conditions of storage and required much attention in their maintenance and repair.

At a later stage the bridging equipment most in demand was the 32 ft. rigid pontoon, very large numbers of which were successfully manufactured by the North Western Railway Workshops, at Moghalpura. Oars were another item which gave scope for the use of Indian timber, the favourites being *dhaman*, *poon* and *pali* in south India and *deodar* in Jhelum, though in the latter case the bigger sizes of naval oar could not be attempted. In addition to the steady demand for ordinary items such as picketing pegs, water-trough frames, drum for cable, carpenters' and fitters' tool boxes, and many other items of signalling equipment such as cable-laying carts, unforeseen demands arose for such unusual items as flexible duck-boards, decking for floating docks, sledges for beach-landed stores, and coastal pontoons and barges for unloading in deep water.

XVII. Tent Poles

The last of our major "flaps" was over the production of astronomical quantities of bamboo tent poles during the latter half of

1943, required for housing the British and American troops which were then pouring eastwards to deal with the Jap. There is only one bamboo which is more or less solid. This is the *bains* or "*male*" bamboo, *Dendrocalamus strictus*, which is found mostly in the Punjab, U. P. and Central Provinces and seldom exceeds 1½ inch diameter. Of the larger hollow bamboos there are a great many different species but very few have a thickness of shell sufficient to carry the metal fittings of a tent pole without splitting. Even the *male* bamboo becomes so thin shelled in areas of greater rainfall that it is unsuitable for even the lighter types of tent pole. For the largest type for store tent, marquees and messtents we had the greatest difficulty in getting supplies for in the areas which produced a good large bamboo there was a complete dearth of skill in fashioning and fitting the metal parts.

Both before and after manufacture the losses in tent poles through borer beetle attack were tremendous. The presence of beetle larvae inside a bamboo is not apparent until the adult beetle hatches out and makes the familiar shot hole as an exit, and as they can produce several generations in a year an epidemic attack can develop surprisingly quickly. By insisting upon early creosoting of all bamboo stores, including tent poles and tent pegs, this scourge was kept down but only after very heavy losses had been incurred, particularly in enclosed goods wagons on long journeys after which a wagon floor was apt to be inches deep in frass.

THE AFFORESTATION OF DRY TEMPERATE HILL SLOPES IN KASHMIR *

By M. L. Mehta

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This problem has received the attention of the research division for several years. The main experiments have been tried at Shankaracharya Hill in the heart of Srinagar and compt. 72 Baramulla.

These sites are situated at North latitude 34′–5° and East longitude 74′–50°. The hill presents all topographical aspects for afforestation. The area before coming over to the research division was practically devoid of vegetation excepting a small patch of about 100 middle aged *kail* (*Pinus excelsa*) trees restricted to about two acres on the eastern aspect of the hill. Grazing was unrestricted.

The soil on the hill is very shallow. Parent rock crops up at very many places. Water supply is absent. There are no springs or streams.

The afforestation of these areas is greatly hampered by climatic, edaphic, and biotic factors. A brief account of these factors is given below :—

Climatic factors

The total rainfall is nearly 27 inches. However this is mostly in the form of snow in the months of December to February. There are spring showers also but these are not well distributed and are mostly erratic.

The concentrated precipitation on a soil which is not very absorbant coupled with the fact that the hill is but a vertical projection in a flat area, and what little gravitational water is absorbed is drained off to lower altitudes, leads to somewhat dry and desert conditions in the rest of the year. June to August are pretty hot and dry. There are not many summer showers. Plant growth which usually starts well in the spring receives a huge set back in the summer drought season. The soil being bare and unabsorbtive, not much water is retained and the drought is all the more accentuated.

Frost is not a big factor here since the species being tried are mostly frost resistant. However frosts do occur and these very effectively narrow down our choice of species.

Edaphic factors

The soil on these slopes is extremely shallow and poor. The steeper hill slopes are practically devoid of soil excepting in small pits.

*Paper read at the 7th All-India Silvicultural Conference (1946), Dehra Dun, on item 3—The afforestation of dry and desert areas

At other places the upper soil has been washed off and the less cohesive subsoil mixed with small stones has come to the surface.

The soil near the existing *kail* patch however is deep and fertile, thus standing testimony to the good effect of vegetative cover on the soil.

Climatic factors

These are the unrestricted grazing by cattle, and destruction by human agency and birds. The first has however now been overcome by strict closure. The hill being situated almost in the heart of the city, damage through human agency, though not wilful, is not at the same time slight. Birds do considerable damage to direct sowings.

The limiting factors as enumerated above are great. As far as could be ascertained from the published literature no such work of afforesting temperate hill slopes had been done in India previously. So no experience could be gained from this country. Afforestation work was being done in other countries. But the conditions prevalent there were so very different that great care had to be exercised in following up their lines of work and choice of species.

Choice of species

A long time was thus spent in making the proper choice of species. In view of the limiting factors our choice of species was narrowed down to those with xerophytic characters, and drought and frost hardiness. Coupled with these was the consideration that the species should be able to grow in almost a raw soil and should be sufficiently fast growing and easy to raise.

A very large number of species were tried first in the nursery. The more promising of these were tried actually on the hill slopes.

Both conifers as well as broadleaved species have been tried on the hill. As a result of the experience gained it is found that broadleaved species, with certain exceptions, always require more exacting soil conditions than the conifers. They do well in shady places with deeper soil and better moisture retaining capacity. They do not stand exposure, excessive heat and drought as well as conifers. However, there are exceptions to these considerations and as yet the most promising species out of both conifers and broadleaved species is *Robinia pseudoacacia*—a broadleaved species. This specie is easy to raise on all aspects and in all soil conditions. It is fast growing and is resistant to drought and frost. At present the first *Robinia* plants sown on the hill side have begun to form seed on Shankaracharya Hill. Other broadleaved species that give a good promise of success are *Ailanthus glandulosa*, apricot, and almond, the last two being not so good as *Robinia* and *Ailanthus.*

Many conifers have been tried. However those with a promise of success are *deodar* (*Cedrus deodara*), *kail* (*Pinus excelsa*) *chil* (*Pinus longifolia*), *Pinus halepensis*, *Pinus canariensis*, and *Cupressus arizonica*.

Out of these the local *deodar* and *kail* do very well on cooler slopes. Their rate of growth however is rather slow in the beginning. *Chil* has given marvellous results in the hotter aspects. *Pinus halepensis* and *Cupressus arizonica* have given indeed very good results. These are easy to raise at all places and are resistant to drought and frost.

Amongst the conifers so far tried *Pinus halepensis* is as yet easily the best. It is quite fast growing and this year this pine has formed cones as well.

As far as the initial choice of species is concerned, the same has already been made by us. However these species are to be planted up in suitable mixture of broadleaved and coniferous trees. But the problem of the proper choice of species can by no means be stated to have been fully solved. As yet the species enumerated above have given satisfactory results. But these need not be the very best for these localities. So a search for new species will continue. Beside this, after the canopy has been once formed, it will be necessary to try other species which could not come in the initial successional stages. Rather it has still to be seen whether the species chosen at present will regenerate themselves naturally or again the whole process of artificial restocking will have to be gone over.

At present a search is being made for plants which will grow in the shallow soil pockets of the bare rugged parent rocks.

Site preparation

In a place like Shankaracharya the obvious method of soil preparation should be such as

to conserve moisture and prevent surface runoff and if possible to store some water. In view of this the original method of planting in pits was abandoned in 1940 and contour trenches on the 'Gradoni' system were adopted. 24 to 30 inches wide and 18 to 20 inches deep trenches are now made before rains. These give much better results than the pits. The percentage of survival is better as also the growth rate. This improvement is all the more noticeable in case of deciduous broadleaved species.

The cost of contour trenching as compared with pits is indeed very high. In view of this, experiments have been started to see the relative merits of different sizes of trenches. As yet 1 foot by 1 foot trenches are also giving quite good results. A further improvement now being followed is to have the slope of the trench towards the hillside. This conserves the run off water better.

Nursery work

The usual nursery technique is followed. The seeds are mostly raised in beds excepting some species which do not stand transplanting easily, *e.g. chil* (*Pinus longifolia*). In their case small baskets are employed.

Pricking out is almost always done. The following categories of plants do best as far as our experience goes :—

1.	*Cedrus deodara*	.. 1,1
2.	*Pinus excelsa*	.. 2,1
3.	*Pinus longifolia*	.. 1,1
4.	*Cupressus arizonica*	.. 1,1
5.	*Pinus halepensis*	.. 1,1

Planting

Season of planting.—Though spring is a very good season for transplanting, it suffers from the handicap of shortness of duration, being at best three or four weeks. Before this, the snow is on the ground and after this period the plants begin their normal growth activities, at which time the survival percentage of these transplants is materially lowered.

There being not much summer monsoon, the question of rainy season transplanting does not arise.

Our experience definitely indicates winter planting as the best. Its chief advantages are the extensive length of the planting period, early formation of new root growth and more rapid growth in the spring. Besides this, plants being in a dormant stage in the beginning of winter, the injuries sustained by the plants in transplanting are not so very damaging. This is especially so in case of broadleaved species.

The winter planting gives one added though indirect advantage. The failures of winter plantings can be replaced in spring. These failures, being not very extensive, can easily be replaced in the short spring period.

Transplanting.—This is done on cloudy days after a few good soaking rains. On clear days there is a greater danger of frost. While transplanting, care is taken that no dry soil comes in contact with the root system. This, as stated above, is obviated by planting after a few good soaking rains.

Some direct sowings have also been tried in the case of broadleaved species. These are still in the initial stages and so as yet nothing can be stated about their success or otherwise.

Other cultural works

After the experience gained, the percentage of success now being attained is indeed very good. Failures are however consistently being replaced. Recent experience suggests that in case of extensive drought, it is better not to get grass etc. cut in these plantations. However this factor is still under experiment and definite prescriptions regarding this cannot be made.

Now at present practically the whole of the Shankaracharya hill excepting the unculturable portions, has been afforested but in view of the vast extent of bare areas in the State, further research work is continuing unabated.

The primary object of afforesting the Shankaracharya hill was to improve its aesthetic appearance. Hence the financial consideration was not paramount. This happy state of conditions is however not going to prevail all through. Quite a lot of work to evolve the best methods of afforesting such bare areas at the cheapest possible rates remains to be done. It is here that parallel work done, in other parts of temperate forests in India would be of the greatest use to us in Kashmir.

UTILIZATION OF MINOR FOREST PRODUCTS, PATIALA STATE

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(A) Indigenous Drugs

The survey of forest flora of the Patiala State, both in the hills and in the plains was undertaken under the direction of the late His Highness the Maharajadhiraj of Patiala in the year 1940-41. Plant specimens were collected in all seasons.

Minor forest products play an important part in adding to the revenue of the forest department. I feel it my duty to publish the report of my survey even after so many years in view of the initiative taken by the director of public relations, chamber of princes, New Delhi, in the utilisation of the "forest wealth" of the Indian state forests.

The following drug plants were found growing wild within the state forests:

Name	Sanskrit or Hindi synonyms	Parts used	Locality where available
1. *Tinospora cordifolia* ..	*Gulancha* ..	Whole herb ..	Plains, Pinjore
2. *Berberis asiatica* ..	*Daru-haridra* ..	Wood ..	Pinjore, Solon
3. *Viola odorata* ..	*Banafshah* ..	Whole herb ..	Chail, Kufri
4. *Sida cordifolia* and other species	*Bala* ..	Root ..	Pinjore
5. *Pavonia odorata* ..	*Sugandha-Bala* ..	Root ..	Pinjore
6. *Zanthoxylum alatum* and *Z. budrunga* ..	*Tambul* ..	Seed ..	Pinjore
7. *Aegle marmelos* ..	*Bel* ..	Fruit ..	Plains, Pinjore
8. *Boswellia serrata* ..	*Gugal* ..	Gum-resin ..	Pinjore
9. *Melia azadirachta* ..	*Nimb* ..	Bark and seeds ..	Plains
10. *Euonymus tingens* ..	*Paper* ..	Bark and leaves ..	Kandaghat, Chail
11. *Vitis quadrangularis* ..	*Harjora* ..	Stalk ..	Plains
12. *Pistacia integerrima* ..	*Kakra-singhi* ..	Galls ..	Pinjore, Solon, Kandaghat
13. *Abrus precatorius* ..	*Ganj* ..	Seeds, roots ..	Plains, Pinjore
14. *Erythrina indica* ..	*Mandar* ..	Bark ..	Plains, Pinjore
15. *Caesalpinia bonducella* ..	*Kat-Karanj* ..	Seeds ..	Pinjore
16. *Cassia fistula* ..	*Amaltas* ..	Pods ..	Plains, Pinjore
17. *Acacia sp.*	*Acacia gum* ..	Gum ..	Pinjore
18. *Acacia Catechu* ..	*Katha*	Extract of wood ..	Pinjore
19. *Rosa sp.*	*Gulab-ka-phul* ..	Petals ..	Pinjore, Solon, Kandaghat
20. *Saxifraga ligulata* ..	*Pashan-bheda* ..	Rhizome ..	Kufri
21. *Terminalia chebula* ..	*Har*	Fruit ..	Pinjore
22. *Terminalia belerica* ..	*Bahera*	Fruit ..	Pinjore
23. *Terminalia arjuna* ..	*Arjan*	Bark ..	Pinjore
24. *Eugenia jambolana* ..	*Jaman*	Bark, seeds ..	Plains, Pinjore
25. *Woodfordia floribunda* ..	*Dhabi*	Flower ..	Pinjore, Solon
26. *Citrullus colocynthis* ..	*Indryan*	Fruit, root ..	Pinjore
27. *Tricosanthes palmata* ..	*Lal-indryan* ..	Fruit, root ..	Pinjore
28. *Corallocarpus epigaea* ..	*Mahamula*	Tubers ..	Pinjore
29. *Trianthema monogyna* ..	*Bish-Kapra* ..	Root ..	Pinjore
30. *Hydrocotyle asiatica* ..	*Brahma-Manduki* ..	Whole herb ..	Pinjore
31. *Oldenlandia corymbosa* ..	*Pitpapra*	Whole herb ..	Pinjore
32. *Paederia foetida* ..	*Gandhali*	Whole herb ..	Pinjore
33. *Rubia cordifolia* ..	*Manjistha*	Roots ..	Pinjore
34. *Nardostachys jatamansi* ..	*Jatamansi*	Rhizome ..	Kandaghat
35. *Taraxacum officinale* ..	*Kanphul*	Root ..	Pinjore
36. *Plumbago rosea* ..	*Chitrak*	Bark ..	Plains, Pinjore
37. *Embellia ribes* ..	*Viranga*	Berries ..	Pinjore
38. *Symplocos racemosa* ..	*Lodhra*	Bark ..	Pinjore
39. *Astonia Scholaris* ..	*Chhatian*	Bark ..	Pinjore
40. *Hollarhena antidysenterica*	*Kataja, Indrajab* ..	Bark, seeds ..	Pinjore
41. *Hemidesmus indicus* ..	*Ananta-mul* ..	Roots ..	Pinjore
42. *Cordia obliqua* ..	*Lasora*	Fruit ..	Pinjore, Solon
43. *Ipomoea digitata* ..	*Bhumi-Kusmanda* ..	Root ..	Pinjore
44. *Solanum indicum* ..	*Virhati*	Fruit, root ..	Plains, Pinjore

	Name	Sanskrit or Hindi synonyms	Parts used	Locality where available
45.	*Solanum xanthocarpum* ..	*Kanti-kari*	Whole herb ..	Plains, Pinjore
46.	*Withania somnifera* ..	*Aswagandha* ..	Roots, leaves ..	Pinjore
47.	*Herpestis monniera* ..	*Jala-brahmi* ..	Whole herb ..	Plains, Pinjore
48.	*Hygrophila spinosa* ..	*Talmakhana* ..	Whole herb ..	Pinjore
49.	*Andrographis paniculata* ..	*Kiryat*	Whole herb ..	Pinjore
50.	*Adhatoda vasica* ..	*Bansa*	Leaves, bark ..	Pinjore
51.	*Vitex trifolia* ..	*Nisinda*	Whole herb ..	Plains, Pinjore
52.	*Boerhaavia repens* ..	*Punarnava*	Whole herb ..	Plains, Pinjore
53.	*Achyrantyus aspera* ..	*Chirchira*	Whole herb ..	Plains, Pinjore
54.	*Euphorbia pilulifera* ..	*Dhudhi*	Whole herb ..	Plains, Pinjore
55.	*Phyllanthus embelica* ..	*Amla*	Fruit ..	Plains, Pinjore
56.	*Putranjiva Roxburghii* ..	*Jia-pota*	Nuts, Bark ..	Plains, Pinjore
57.	*Cannabis sativa* ..	*Bhang*	Leaves, female flowers, resins	Pinjore
58.	*Orchis laxiflora* ..	*Saleb-misri* ..	Tubers ..	Chail, Kufri
59.	*Eulophia nuda* ..	*Bhuin-kakali* ..	Tubers ..	Kufri
60.	*Urginea indica* ..	*Jangli-piyaj* ..	Bulb ..	Pinjore
61.	*Asperagus racemosus* ..	*Satavari*	Roots ..	Pinjore
62.	*Amorphophalus campanulata*	*Jimi-kand*	Roots ..	Pinjore
63	*Cyperus rotundus* ..	*Mootha*	Tubers ..	Plains, Pinjore

The soil and climatic conditions of Patiala State forests are suitable for the cultivation of the following species of drugs. Intensive cultivation of indigenous drugs in the waste lands, specially in the Ghagar basin will, to a great extent, reduce the soil erosion taking place.

	Name.	Sanskrit or Hindi synonyms	Parts used	Locality where their cultivation could be taken up
1.	*Aconitum ferox* and other sp.	*Bikh, Ates.* ..	Roots ..	Chail, Kufri
2.	*Nigellia sativa* ..	*Kala-jeera*	Seeds ..	Solon, Kandaghat
3.	*Podophyllum emodi* ..	*Papra*	Rhizome ..	Chail, Kufri
4.	*Papaver somniferum* ..	*Afin*	Seed, gum ..	Borog, Solon, Kandaghat
5.	*Hibiscus abelmoschus* ..	*Muskh-dana*	Seeds ..	Plains, Pinjore
6.	*Abroma augusta* ..	*Ulat-Kambal* ..	Wood ..	Plains, Pinjore
7.	*Tribulus terrestris* ..	*Chota-gokhuru* ..	Seed ..	Plains, Pinjore
8.	*Psoralia corylifolia* ..	*Buchki*	Seed ..	Plains, Pinjore
9.	*Saraca Indica* ..	*Ashok*	Bark	Plains, Pinjore
10.	*Cassia angustifolia* ..	*Sona-mukhi* ..	Leaves ..	Plains, Pinjore
11.	*Apium graveolens* ..	*Ajmod, Celery* ..	Seeds ..	Solon, Kandaghat
12.	*Cinchona ledgerina*, and C. Sp.	.. ..	Bark ..	Kandaghat, Chail, Kufr
13.	*Valeriana Wallichii* ..	*Nandyavarta* ..	Rhizome ..	Chail
14.	*Vernonia anthelmintica* ..	*Somraj*	Fruit ..	Plains, Pinjore
15.	*Matricaria Chammomilla*	*Babune-ke-phul* ..	Flowers ..	Kandaghat
16.	*Artemisia Vulgaris* and *A. maritima*	*Nagdamini* ..	Whole herb ..	Chail, Kufri
17.	*Sanssuria lappa* ..	*Kutaja*	Root ..	Kufri
18.	*Carthamus tinctorius* ..	*Kusumba*	Flower ..	Kandaghat, Chail
19.	*Cichorium intybus* ..	*Kasni*	Seeds ..	Solon, Kandaghat
20.	*Rauwolfia serpentina* ..	Sarpagandha ..	Root ..	Plains, Pinjore
21.	*Strychnos nux-vomica* ..	*Kuchila*	Seed ..	Pinjore
22.	*Atropa belladonna* ..	.. .. ..	Roots, leaves ..	Kandaghat, Chail, Kufri
23.	*Datura Stramonium* ..	.. .. ..	Seeds, leaves ..	Plains, Pinjore
24.	*Hyoscyamus reticulatus* and *H. niger*	*Khorasani-Ajwan* ..	Leaves, seeds ..	Plains, Pinjore
25.	*Picrorhiza kurrowa* ..	*Katki*	Roots ..	Chail, Kufri
26.	*Plantago ovata* ..	*Isabgul*	Seeds ..	Solon, Kandaghat
27.	*Piper longum* ..	*Pipal*	Fruits ..	Pinjore
28.	*Crotton tiglium* ..	*Joypal*	Fruits ..	Pinjore
29.	*Ephedra Vulgaris* and *E. pachyclada*	.. ..	Whole herb ..	Kandaghat, Chail
30.	*Curcuma longa* ..	*Haldi*	Tubers ..	Pinjore
31.	*Zigiber officinale* ..	*Adrak*	Tubers ..	Pinjore

In addition to plants listed above, I would suggest the extensive plantation of the following grass and trees of economic importance :—

(1) *Catechu* trees,
(2) *Eucalyptus* trees,
(3) Lemon grass.

in the Ghagar basin and adjoining Siwalik Hills ; and the cultivation *Pyrethrum* at Kandaghat and chail.

My thanks go to the Raj Baidyaji who took trouble to accompany me during the occasional survey tours I conducted within the state.

EXTRACTS

USE YOUR SOIL WISELY

By J. L. Goheen.

To speak of "the pressure of the population on the land" in India may be trite. The language is figurative because actually it is the demand made on the land for the production of crops for man and beast which is the 'pressure' implied. True, the average density of the population is high and it probably will continue to become higher. With such soil and climate as most of this subcontinent possesses it is but natural that this should be so.

If man and beast are to live well and happily it is essential that all due attention be paid to the soil upon which they have to live. This subject is so important that it should receive greater thought and attention. It simply is not possible to take out of the soil what is not there. The need for moisture during the uncertain monsoon seasons and, more especially, during the seasons of little or no rainfall is apparent. Therefore, it is gratifying that serious steps are being taken to increase the acreage in India under irrigation. Even though that acreage is the highest of any large country on the face of the earth it is not enough. Much more land needs to be given the blessing of sufficient moisture.

That blessing, however, may not be an unmixed one, because with the addition of moisture come other problems. There may be those of drainage, of the removal of alkaline salts, or of giving periods of rest to overworked soils. These matters cannot be overlooked. In other words, the addition of moisture itself is, by no means, the great cure-all for the heavy pressure on the soil. This subject must be scientifically handled.

Just as important as the addition of moisture is the addition of organic matter such as decomposed manure, compost, humus, vegetable matter, or whatever one may wish to call it. Those who till the soil in order to produce crops ought to realise as perhaps they never have yet realised that vegetable matter must be conserved and supplied faithfully to that soil. This is one of the great lessons which the cultivator all over India, generally speaking, needs to learn. He needs to realise that vegetable matter in the soil serves to absorb moisture and act as a sponge, giving up that moisture as the roots of the plant draw upon it. That matter furnishes not only the necessary nutrients for the healthy growth of plants, but to a certain extent at least, through the return of mineral matter, enables the soil to yield back in the crops produced the essential elements for healthy growth in man and beast.

The above-mentioned facts are fairly commonplace. The *Allahabad Farmer* recommends, in these days of increasing pressure on the soil, that a nation-wide campaign to utilize all the available manure and organic matter, of whatever sort, for the maintenance of soil fertility should be waged. Such a campaign should be positive and important part of the general "Grow more Food" campaign. Instead of burning cowdung let there be a nation-wide campaign to produce quick growing economic plants such as caster beans, *Sesbania aegyptica* and others of similar characteristics which have fuel possibilities: and at the same time the slower-growing more permanent trees with fuel, fruit and timber possibilities. There should be a nation-wide observance of tree planting day, or days, at suitable times in the monsoon periods to be observed as faithfully as the observance of the main religious festivals.

Along with this campaign there should be a similar campaign waged for the conservation of all manure and organic matter of whatever sort. Demonstrations of the best method or methods, of preparing and storing then applying this valuable material to the soil should be conducted vigorously throughout the whole countryside. The soil will soon begin to demonstrate the value of such consideration for it.

Let every one realise that the soil of India is her best material possession. It must be conserved and reclaimed wherever possible: its fertility must be maintained and increased. It may be necessary to use it intensively: but if so, let it be used wisely. Let it not be robbed nor depleted. Let it have its necessary rest (holiday) periods. Let not weeds infest it. Let every square inch be used to the best possible advantage. Let there be a fresh recognition of man's responsibility to the soil. Let India learn to value her soils and employ sound sense and science to conserve and utilize them.

—*The Allahabad Farmer*, Vol. XX, No. 3, May 1946.

FIRE EDUCATION—DOES IT PAY?

BERNARD L. ORELL.

First lieutenant, Signal Corps; formerly with the Oregon State Board of Forestry. Junior member, S. A. F.

A much discussed question among foresters has always been, "What are the returns of the fire prevention efforts of the various protection agencies?" All agree that we must have an organized public education program if we are to lower the number of fires caused by carelessness with cigarettes, camp fires, ash dumping, and incendiarism. As the results of such a program are intangible almost impossible to measure, the agreement as to the scope and justifiable expenditure of money varies widely.

Experience at Camp Adair, Oregon, during the fire seasons of 1943 and 1945 made possible some degree of measurement and gives a true indication of the real value of a concentrated fire education program. Camp Adair is situated on the western edge of the inflammable Willamette Valley. All the factors of fire danger are present, a dry summer season and thousands of acres of dry-matted grass lands which merge into brush and fern areas and then into the timbered foothills of the Coast Range. Into this tinder box of 57,000 acres

were brought some 40,000 newly drafted soldiers from all walks of life, largely from the industrial centers of the Midwest and East. The average new soldier taken from this group, or any similar group, is probably the most irresponsible individual in the world. He has been plucked from home and friends and is unhampered by many of the conventions under which he grew to manhood. The potential fire problem immediately assumed acute proportions.

It was realized that many fires caused by the use of tracer and high explosive ammunition could not be avoided. Advance preparation in the way of fire breaks and early season burning, however, could minimize this danger to some degree. In order to have the time, personnel, and equipment to take care of these unavoidable fires, it was necessary to limit in so far as possible the tremendous hazard stemming from careless use of fire by the large numbers of troops in the restricted area. An intensive educational program was initiated. Warning signs at all road entrances to the range were posted, posters furnished by the U. S. Forest Service and the Keep Oregon Green Association were placed on all bulletin boards, and the camp paper and other publications carried weekly and daily reminders of the danger of fire.

In addition, fire fighting crews were trained and established in each unit. With the aid of the Oregon State Board of Forestry and the Siuslaw National Forest some 1,000 commissioned and non-commissioned officers were trained intensively in methods of fighting fire. This training was highlighted by moving pictures, organization and fundamentals of fire fighting, demonstrations, the building of fire trail through typical terrain, and by actual work on small fires. These men in turn trained somewhat less intensively about 12,000 additional men.

What were the results? During the summer of 1943 the Range Fire Detail fought successfully 107 fires ranging from one-quarter acre to 250 acres in size. Troop units themselves put out 15 other fires without assistance. Of these 122 fires the causes are shown in Table 1.

The only reasonable conclusion that can be drawn from the figures is that the time and effort expended on the training program paid handsomely. Had the incidence of carelessly caused fires been anywhere near the normal expectation the situation would have been extremely dangerous.

Peculiar circumstances, however, pointed up this conclusion even more strongly during the maneuvers near Bend in eastern Oregon during this same season of 1943. One of the divisions activated at Adair left the post for another north-west station in March. As a result of the move this outfit was not exposed to the educational program conducted in April and May. This division went into the maneuver area in July, a month not particularly dry as it was characterized by weather with high humidity and some precipitation. State Forester Nelson S. Rogers reported an extremely high fire incidence during this period caused by the careless handling of fire by troops. State protection forces were taxed to the utmost to prevent dangerous uncontrolled fires.

Table 1.—Comparison of 1943 and 1945 Fire Seasons

Cause	Number 1943	Number 1945	Per cent 1943	Per cent 1945
Tracer ammunition	56	5	45.9	8.2
High explosive shells	44	11	36.1	18.0
Bangalore torpedoes	6	0	4.9	0.0
Live grenades	8	8	6.6	13.1
Bivouac fires	2	1	1.6	1.6
Lightning	1	2	0.8	3.3
Cigarettes	3	26	2.5	42.6
Incendiary	0	5	0.0	8.2
Others	2	3	1.6	5.0
Total	122	61	100.0	100.0

The 104th Division, however, left Adair to go directly into the maneuver area late in August when the fire season was at its height. During its stay, this division which had received the full benefit of the training effort, started only a few fires and these were handled by the troops themselves. Effective training on the one hand indisputedly had reduced the fire incidence to a real minimum.

The season of 1945 opened on an entirely different situation than that which had existed in the early days of the camp. Originally a division training center where the units remained at least nine months with a relatively small personnel change, Camp Adair was reactivated as a Ground Forces Replacement Depot. Replacements destined for overseas combat duty paused there for last minute checkups in clothing, equipment, records, and training. The average tenure of each individual was ten days with a complete personnel turnover, excepting the regular cadre, three times a

month. The maximum number of troops at any one time was 20,000, dropping to as low as 5,000 as overseas demands fluctuated.

When the first replacement troops arrived the fire season was well advanced. This fact, coupled with the obvious impracticability of training such a fluctuating personnel, limited the educational effort to posters, signs, and publicity, the effect of which was small as the individual soldier was not on hand long enough to learn his lesson. Table 1 shows the 1945 fire season as compared to the 1943 season.

The 1943 season was worse than the 1945 season in all respects except that of cigarette and incendiary fires. The smaller total number of fires in the 1945 season is due in part, of course, to the smaller number of troops. Also the complete change of mission allowed presuppression activities to be much more effective and only limited amounts of tracer ammunition were used. Therefore, while planning, early season burning, and the elimination of some hazardous agents materially reduced the expected fires, the impossibility of training the troops brought about a tremendous increase in the percentage of carelessly or maliciously caused fires. Had this load been superimposed on the 1943 season effective fire control with reasonable forces would have been impossible. Had the proportion that did occur in 1943 been in the same ratio in 1945 the margin of safety would have been high and the area burned by the unavoidable fires would have been considerably less. Intensive fire education in 1943 paid for the effort expended in terms of efficient fire control, decreased loss of military and civilian property, and in uninterrupted training time of future combat troops. Lack of such training in 1945 caused a 48 per cent increase in the ratio of carelessly caused fires, the most serious result of which was interference with vital military training.

These conclusions apply equally to the military and to the civilian fire problem. Every effort expended in placing fire and its hazards before the public is well repaid. The instilling of fire awareness into the collective minds of irresponsible soldiers was successfully accomplished with notable results. The number of fires caused by the careless public can be reduced in direct proportion to the intensity of the fire education to which it is exposed.

—*Journal of Forestry*, Vol. 44, No. 9, September 1946.

DRYING WOOD BY KILN

Control Methods—Respective Merits of Automatic and Hand Operation—Complications that Increase Risks

BY MAJOR F. M. OLIPHANT.

[*During the later years of the war there was a considerable increase in this country's kiln-drying capacity, largely stimulated by Treasury aid. Despite this, due to the comparative scarcity of wood and the tremendous demand for all descriptions, timber cannot be dried quickly enough for consumers. The subject of kiln-drying is therefore very much in the mind of members of the trade in these days, and they may find a good deal to interest them in the following letter.*—ED.]

There is considerable argument to-day concerning the respective merits of automatic as against hand control of timber-drying kilns. It seems to me that you might do a real service by opening your columns to a thorough discussion of this matter. If you agree to this, perhaps I may be allowed to initiate the discussion by offering the following remarks, on the plea that I have been closely connected with kiln-drying and kiln design for many years, first in Canada and the States, and afterwards as Assistant Director of the Forest Products Research Laboratory, Princes Risborough, where I was responsible for the introduction from the States, for research purposes, of the first kiln to be a scientific improvement on the external blower kiln, then in use here. This kiln, although its design was based on a much better appreciation of the scientific principle governing the process, turned out to have disabilities precluding its adoption for commercial purposes, and we later introduced the internal fan kiln, since developed here to suit our own conditions, and adopted as the standard equipment of this country.

No Kiln Entirely Automatic

My remarks are primarily from the point of view of conditions in Africa.

Automatic control *does not mean* merely pressing a button and the control does the rest. No kiln is entirely automatic, and in fact any kiln depends much more on the efficacy of the operator than on the efficacy, less or more, of the design. Engineering maintenance services are also obviously required. The slogan for the tropics, certainly those regions which are remote from first-class engineering advice and ready service on the occasion of a serious breakdown, is "simplicity and strength." The fewer complications the better. If this be agreed, it seems hard to gainsay that hand control is a much safer proposition than automatic—it is simple and there is far less to go wrong.

The more complicated automatic control demands greater engineering knowledge and makes it essential that the mill staff should include a more highly trained engineer to maintain the installation. In the tropics this means not one but two engineers, to replace each other during periods of leave in the United Kingdom and in case of sickness, at an overhead cost which is the greater because of the high cost of European personnel in the tropics. In addition, the extra cost of the equipment is considerable—some 20 per cent, probably, on the capital cost of hand control; the extra equipment includes diaphragm valves, air compressors, pressure switches, and automatic devices to (1) stop the motors, (2) effect a pause until the fan shaft comes to rest, (3) re-start the motors in the reverse direction, (4) to do all this every 15 minutes.

Air Circulation

For those unacquainted with automatic control, it may be explained that reversal every 15 minutes instead of about every 24 hours is made necessary because the bulbs actuating the automatic control are fixed on *one side wall only, and consequently condition* the air to the temperature and humidity required only when it is circulating in the direction of steam-coils—bulbs—stack. When the circulation is reversed, the air passes through the stack *before coming in contact* with the bulbs. In passing through the stack, the air falls in temperature and increases in humidity. So the bulbs, being no longer on the inlet side where the entering air is at the temperature and humidity proper to the schedule, automatically make an entirely wrong adjustment because they are now influenced by the conditions on what is now the outlet side, and the air on the new inlet side is improperly raised in temperature and reduced in humidity. If this were allowed to continue for long there would be grave risk of damaging the load. To prevent damage it is therefore necessary to switch the direction of circulation back and forth at very short intervals.

Incidentally, it is questionable how much good this does to the motors, especially under tropical conditions. At any rate, all of this increases the risk of mechanical failure and adds to the cost of maintenance. In addition, there are certain disabilities inherent in the system, *such as the possibility of coils* becoming waterlogged and wire-drawing of valves.

In conclusion, I have to apologise that I shall not be here to receive *the brickbats* which may be hurled my way in consequence of these opinions, as I expect to sail for Africa any day, to reside there, but correspondence addressed c/o Editor will reach me.

—*The Timber Traders Journal*, December 7, 1946.

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INDIAN FORESTER

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THE APPLICATION OF AERIAL PHOTOGRAPHY TO ECOLOGY AS EXEMPLIFIED BY THE NATURAL VEGETATION OF CEYLON*

BY V. J. CHAPMAN.

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[Assisted in the field work by C. O. Flemmich, J. L. Harley, C. H. Holmes, A. W. R. Joachim, C. de Rosayro and T. Wyatt-Smith.]

Introduction

After the 1914-18 war the possibilities of air photography in the service of ecology were realised by some workers, and during the next twenty years a few papers on this subject were published. These were mainly concerned with forests in Rhodesia (Dudley Stamp, 1925), Canada and Burma; in the last country two areas were surveyed in detail, the Irrawaddy delta (Kemp, Lewis, Scott and Robbins, 1925) and Tavoy and Lower Tenasserim (Scott and Robbins, 1925). These pioneer investigators showed that much useful information could be gained, whilst different types of forest could be recognised and mapped. In the Tavoy survey as many as thirteen different types of forest were recognised and in the Irrawaddy delta six different types, whilst in both areas quite detailed maps were prepared. As a result of this work suggestions were made for the conduct of future surveys, *e.g.* it was noted that in Burma, February was the month when the distinction between trees was greatest and therefore the period when photographs should be taken. This seasonal aspect is an important point, and if the best ecological results are to be obtained it cannot be disregarded: in the present work it is exemplified at Mundel Lake (p. 313) and also at Puttalam (p. 310). Since these early studies were published considerable advances in photographic techniques have been made, especially during the recent war, and the value of air photographs has increased immensely.

During 1945 an opportunity arose to study certain areas of Ceylon both from the air and from the ground. Ceylon proved a very suitable place for the purpose in hand because there was already in existence a provisional soil map* (*plate* 12), considerable information about the geology and a rainfall map* (*plate* 13). The vegetation of the grasslands and of the forests of the south-west have been studied intensively (Pearson, 1899; Alston, 1938; de Rosayro, 1939, 1943), and three natural vegetation types are represented on the agricultural map (*plate* 14)†. Apart from the grasslands and the forests of the south-west there is relatively little published information about other types of vegetation in Ceylon. The present account provides a brief survey of some of these other communities treated from a particular aspect. For some years the soils of the island have been subjected to detailed study in relation to the different types of natural and cultivated vegetation (Joachim *et al.* 1935-38), and for this reason the soils of the different communities were also investigated during the ground checks.

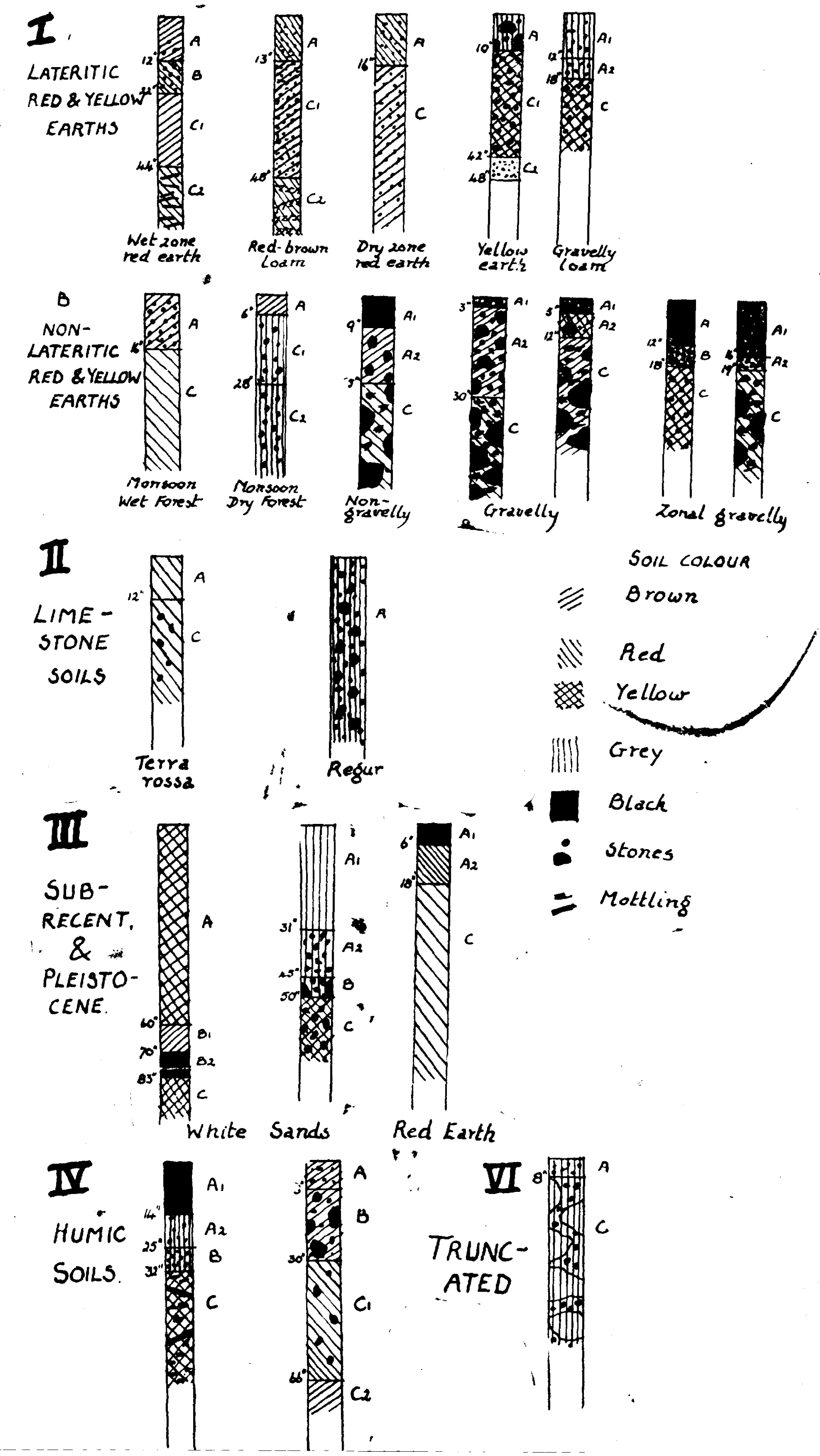
Purpose

It is proposed to describe certain small areas of Ceylon, which are representative of some of the different types of natural vegetation,

*This paper with the photographs is published by permission of the Deptt. of Research, Admiralty, London, and by permission of the Government of Ceylon.

*—*These are reproduced by courtesy of the Govt. Chemist, and Govt. Meteorologist of Ceylon.

†Many of the areas on this map have now been put under cultivation. Furthermore the natural forest vegetation exists in a number of different types which are not represented on the agricultural map.



I
LATERITIC RED & YELLOW EARTHS
Wet zone red earth
Red-brown Loam
Dry zone red earth
Yellow earth
Gravelly loam
B
NON-LATERITIC RED & YELLOW EARTHS
Monsoon Wet Forest
Monsoon Dry Forest
Non-gravelly
Gravelly
Zonal gravelly
II
LIME-STONE SOILS
Terra rossa
Regur
SOIL COLOUR
Brown
Red
Yellow
Grey
Black
Stones
Mottling
III
SUB-RECENT, & PLEISTOCENE.
White Sands
Red Earth
IV
HUMIC SOILS.
VI
TRUNCATED

and to compare them where possible with existing data. In this way some indication can be obtained of the ecological value of the photographs and they will also serve to some extent as types upon which any other air photographs of Ceylon may be interpreted. In order to facilitate the comparisons a brief summary is provided of the different vegetation and soil types so far recognised in the island, including some that are introduced for the first time. For reasons of uniformity the classification of the forest types is based upon that of Champion (1935), with Rosayro's work incorporated. This treatment has been adopted because the Ceylon forests in the north, east and montane regions are very similar in their composition to the forests of south-east India. The forests of the wet south-west on the other hand are more similar to those of Burma and Malaya*. The usual ecological nomenclature has not been adopted for the communities, because the author is well aware that in tropical ecology uniformity has not yet been achieved, and is not perhaps likely to be so until much more work has been carried out. The terminology used is therefore of a non-committal character, except in certain cases (mainly maritime), where the author is of the opinion that normal ecological practice can be employed.

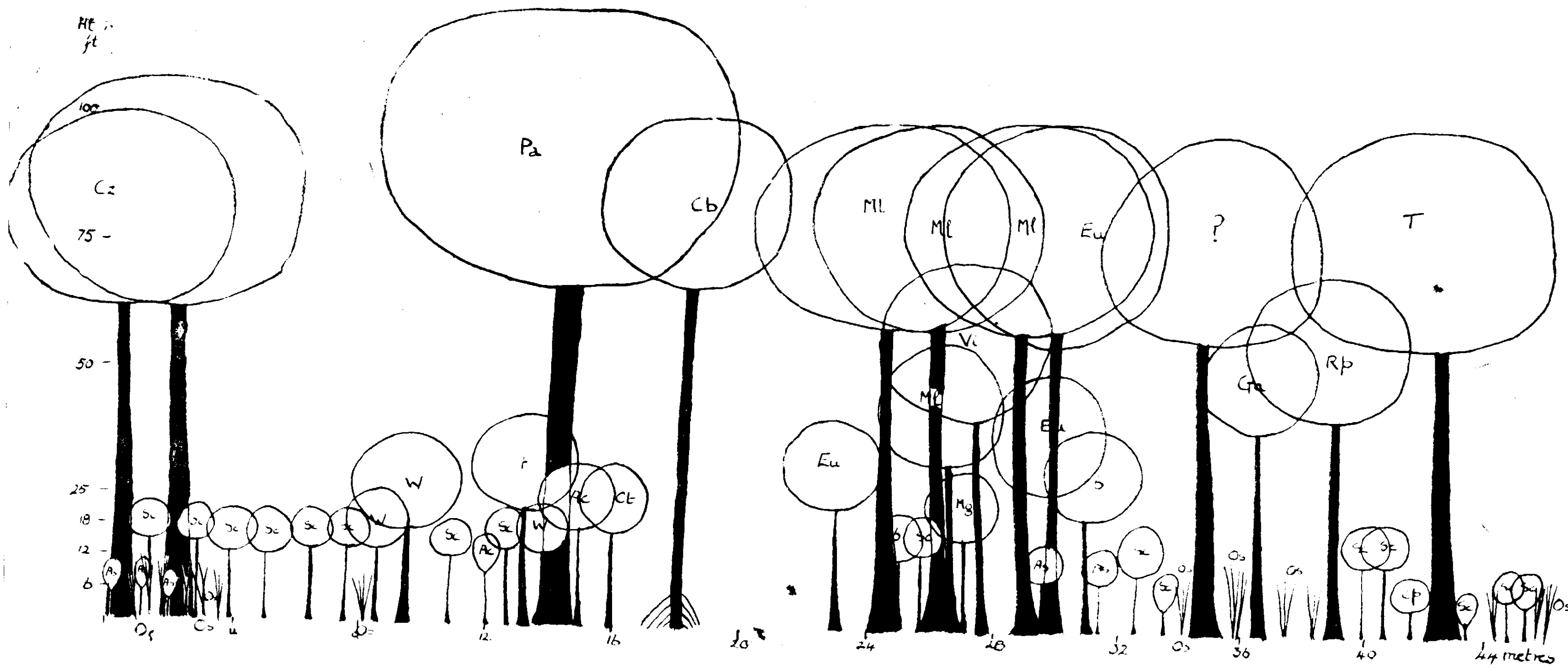
Vegetation types of Ceylon

1. Dipterocarp Forest.
   (a) *Dipterocarpus zeylanicus* (Hora) community.
2. Western Tropical Evergreen Forest.
   (a) *Mesua-Doona* community } (Deniyaya)†
   (b) *Campnosperma* community } (Deniyaya)†
   (c) *Vitex-Wormia-Chaetocarpus-Anisophyllea* community (Ratnapura).
3. Moist Tropical Semi-evergreen Forest (Wellawaya).
4. Tropical Savannah.
   (a) Moist Savannah community (*Anogeissus-Careya-Cymbopogon-Imperata* Association) (Wellawaya).
5. South Tropical Moist Deciduous Forest (Buttala).
6. Montane Temperate Forest.
   (a) Southern Wet Temperate community (Ambawela).
7. Tropical Dry Evergreen Forest.
   (a) *Manilkara* community (Hambantota, Vellankulam).
   (b) *Manilkara-Hemicyclia* community (Komari).
   (c) *Manilkara-Hemicyclia-Chloroxylon* community (Puttalam Nachchikuddi).
   (d) *Manilkara-Chloroxylon-Eugenia-Vitex* community (Oddisuddan, Kandavalai).
8. Southern Thorn Forest.
   (a) *Hemicyclia-Euphorbia* Semi-desert Scrub (Hambantota).
   (b) *Acacia* Thorn Scrub (Vellankulam).
9. (a) Secondary Forest Growth (Serial stages of all forest types).
   (b) Kekilla (fernlands).
10. Tropical Beach Forest formation.
    (a) Beach Scrub (Komari).
11. Eastern Tropical Sand Dune formation.
    (a) *Spinifex-Ipomoea-Scaevola* Association (Komari).
12. Eastern Mangrove formation.
    (a) *Rhizophora* consociation (Batticaloa).
    (b) *Avicennia intermedia* consociation (Batticaloa, Viddataltivu).
13. Tropical Submarine Phanerogam formation.
    (a) *Cymodocea—Enhalus-Halophila* Association (Puttalam, Mundel Lake, Nachchikuddi, Jaffna etc.).
14. Tropical Salt Flat formation.
    (a) *Suaeda* association (Puttalam, Mullativu, Mundel).
    (b) *Salicornia* Association (Puttalam, Mannar, Nachchikuddi).
    (c) *Scirpus littoralis-Cyperus Haspan* Association (Mundel, Mullativu).
    (d) *Zoisia pungens* Consociation (Nachchikuddi).

*This similarity is perhaps more apparent than real. It is largely based on the presence of Dipterocarps, but a number of these in Ceylon are endemics due to the early isolation of Ceylon from the mainland (Symington 1944).

†Places where type of vegetation was investigated.

RATNAPURA



Profile of a strip of the Vitex-Wormia-Chaetocarpus-Anisophyllea forest at Ratnapura. In this and the subsequent profiles the crowns are purely diagrammatic and there are no measurements for the height of the first branches. Bole size is approximately correct.

Cz = *Campnosperma zeylanicum*
Os = *Ochlandra stridula.*
Mg = *Memecylon gracillimum*
As = *Apama siliquosa*
Cp = *Cleistanthus pallidus*
Sc = *Schumacheria castanaefolia*
Ml = *Myristica dactyloides*
G = *Garcinia sp.*
Pa = *Palaquium sp.*
T = *Terminalia sp.*
Ac = *Anisophyllea cinnamomum*
W = *Wormia triquetra*
Cb = *Caralli brachiata*
Eu = *Eugenia sp.*
Ct = *Calophyllum thwaitesii*
Vi = *Vitex sp.*

15. Tropical Grassland formation.
   (a) Wet *Patana** (*Chrysopogon zeylanicus-Arundinella villosa* association).
   (b) Dry *Patana* (*Cymbopogon confertiflorus-Imperata arundinacea* association) (Bandarawela).
   (c) *Talawa*† and *Damana*‡ land (Mahaweli Ganga).

16. Tropical Freshwater Marsh (Puttalam).

17. Tropical Freshwater Benthos (Tanks with permanent water).

This list does not pretend to be complete, but it covers the principal types of vegetation encountered. Tpyes (1) and (2 a and b) were investigated on the ground at Deniyaya, but no air photographs could be obtained owing to unfavourable monsoon weather.

Soil types of Ceylon (*vide page 288*).

The classification of these is based upon the recent survey by Joachim (1945).

1. Zonal soils in which climate is the dominant soil-characterizing factor. These include :—
   (i) the reddish to yellowish laterite soils and lateritic loams formed under conditions of high rainfall and temperatures and derived from igneous and gneissic rocks.
   (ii) the red, reddish brown, and dark grey lateritic and non-lateritic loams of the "dry zone" of the Island with an annual rainfall of 40-75 inches, also derived from igneous and gneissic rocks.

2. Intrazonal soils associated with limsetone. They comprise :—
   (i) the brick red loams (*terra rossa*) derived from Miocene limestone in the North and North-west of the island.
   (ii) the grey calcareous loams (*rendzinas*) also derived from Miocene limestone.
   (iii) soils similar to the black cotton soils of India and associated with Miocene or dolomitic limestone.
   (iv) the chocolate red loams associated with or derived from crystalline limestone, mainly dolomite.
   (v) a small area of red loams over sandstone associated with Jurassic limestone.

3. Soils derived from Pleistocene and sub-recent deposits :
   (i) the red and brown sandy loams.
   (ii) the bleached white sands (cinnamon soils) and the coastal sands.

4. The humic soils overlying reddish yellow laterite and lateritic loams and clays, including :
   (i) the wet grassland (*patana*) soils.
   (ii) the dry grassland (*patana*) soils.
   (iii) the fernland (*kekilla*) soils.
   (iv) the low-lying peaty soils and *deniya* soils.

5. Azonal soils :
   (i) alluvial silts and loams.
   (ii) the paddy soils.

Small extents of intrazonal alkali soils exist in isolated patches in the semi-arid dry zone of the island.

Photography

The photography of the areas selected for study was carried out on two separate occasions, one series in May and the other in August and September. In May the plane flew at 6,000 ft above ground level, so that the scale of the resulting photographs 1/9,000 was approximately uniform. These photographs were taken with a green filter (type X 450) using an F_8 lens. In August and September the plane flew at 3,000 ft. above ground level, and a green (August) or normal yellow filter (September) was used with an F_6 lens. The scale of the resulting photographs was approximately uniform at 1/7,200 From these flights the ecological value of two different types of filter could be assessed in relation to the different types of vegetation, and also any seasonal changes in the vegetation would become apparent. The majority of the photographs are reproduced as stereo-pairs, as only by this means is it possible for full ecological interpretation to be made.

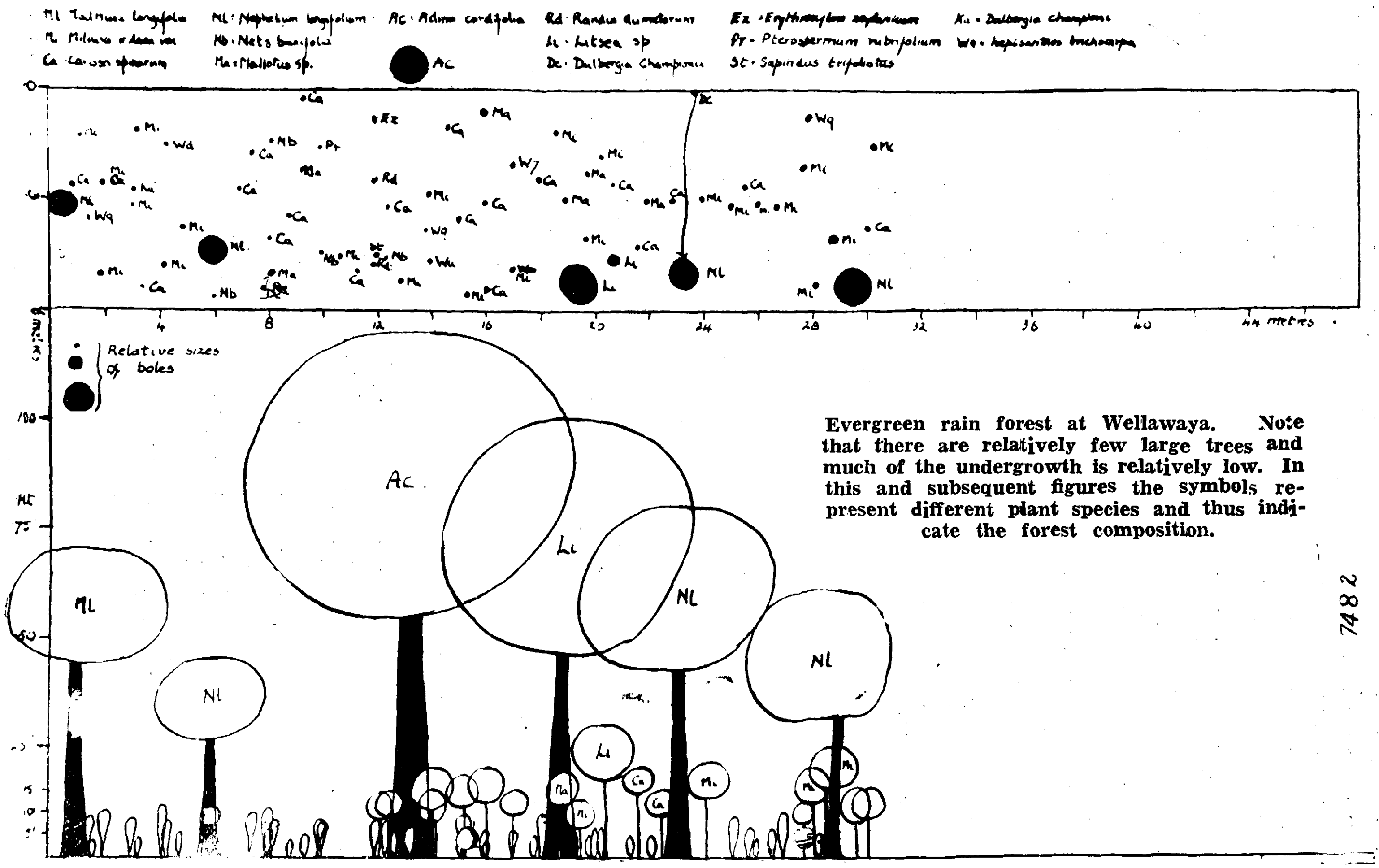
Ground Surveys

These were carried out after the first set of photographs had been obtained. In forest vegetation, so far as possible, a typical site

**Patana* is a local term for montane grassland.
†*Talawa* is a local term for lowland grassland of wet zone.
‡*Damana* is a local term for lowland parkland of the dry zone (with grass predominating).

7482

WELLAWAYA



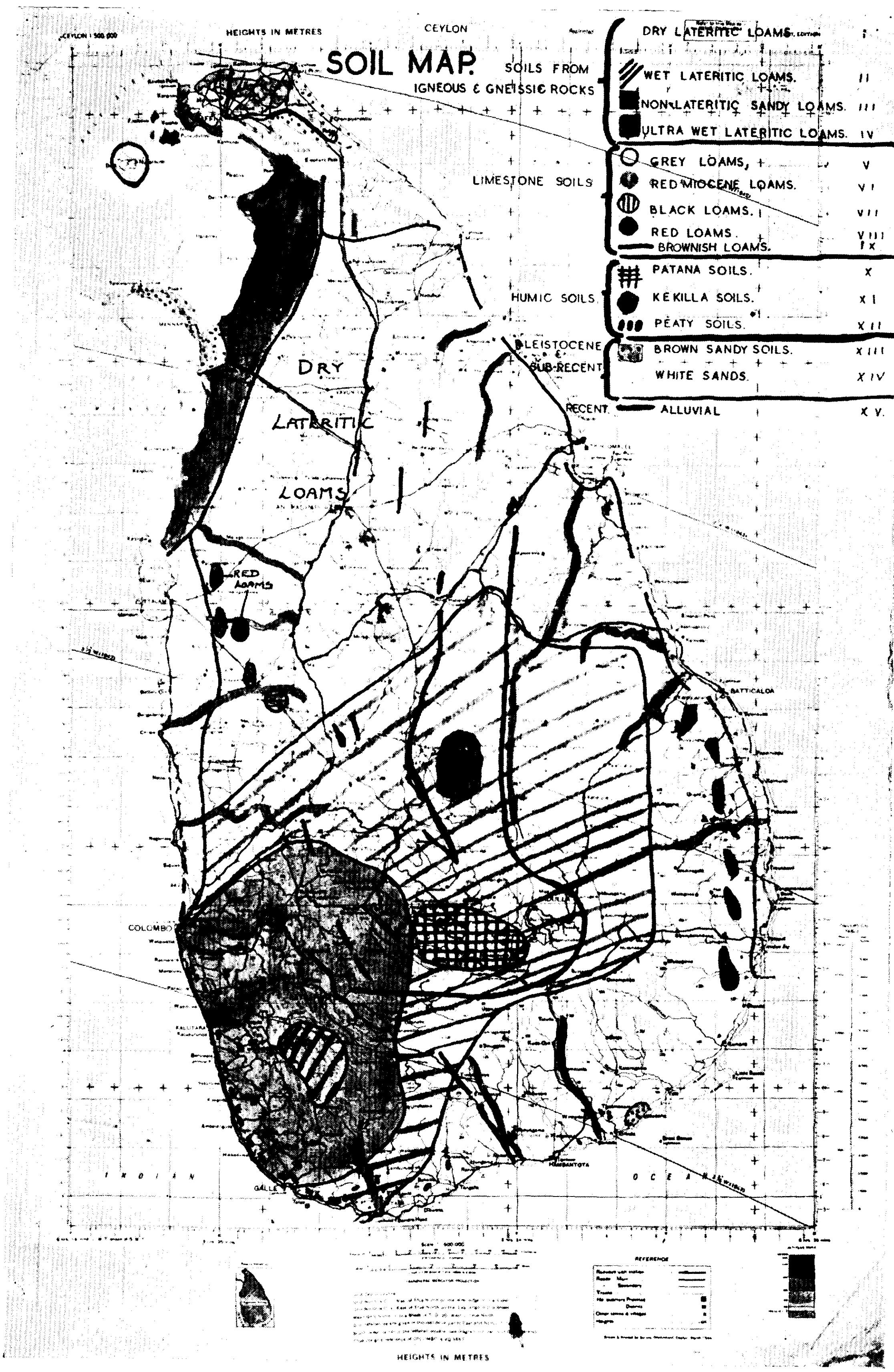
Evergreen rain forest at Wellawaya. Note that there are relatively few large trees and much of the undergrowth is relatively low. In this and subsequent figures the symbols represent different plant species and thus indicate the forest composition.

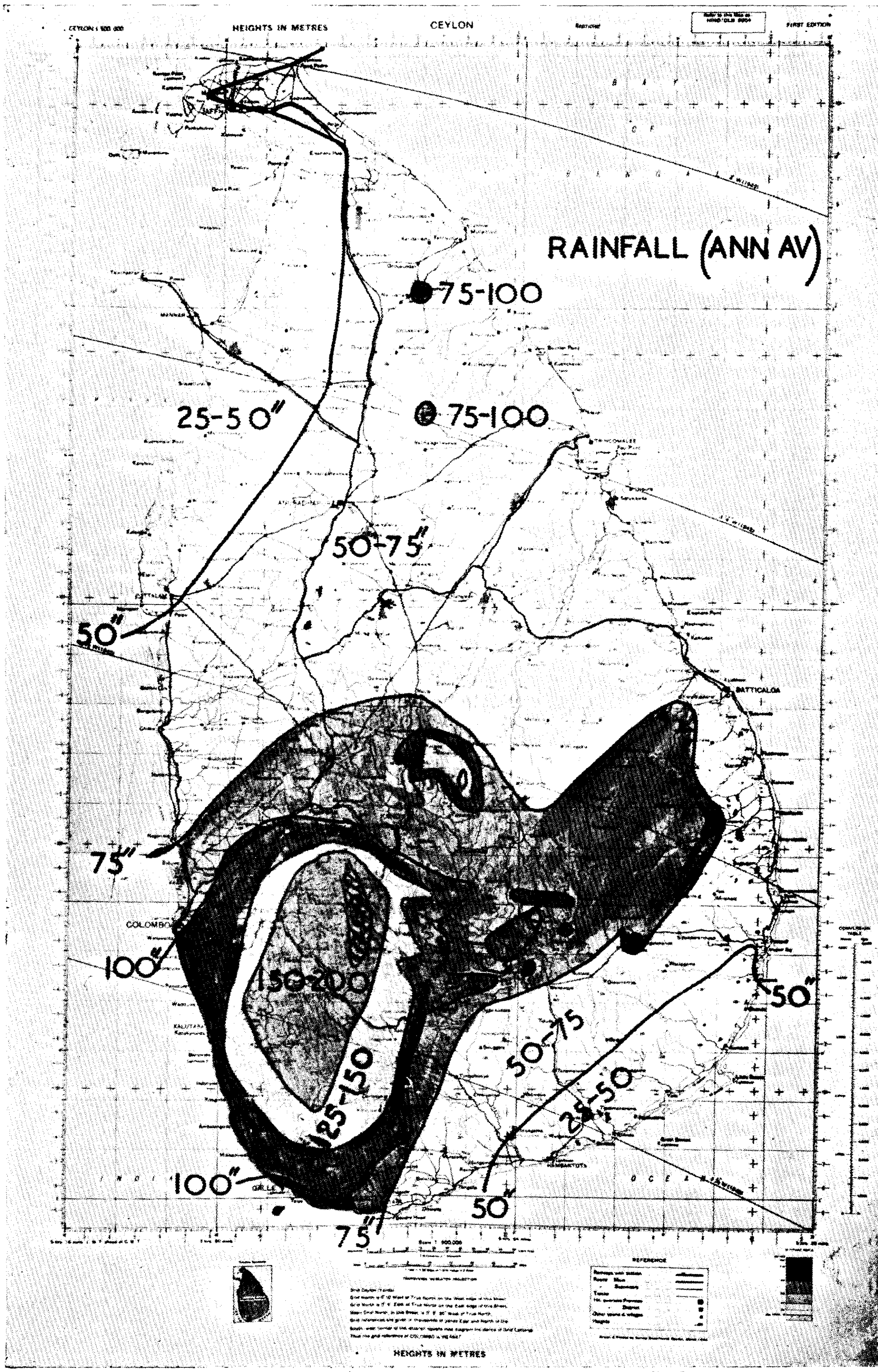
Ml = *Madhuca longifolia*
Ez = *Erythroxylon zeylanicum*
Li = *Litsea sp.*
Ma = *Mallotus sp.*

Nl = *Nephelium longifolium*
Ka = *Dalbergia championi*
Pr = *Pterospermum rubrifolium*

Ac = *Adina cordifolia*
Mi = *Miliusa indusa var.*
Wg = *Lepisanthes trichocarpa*
Dc = *Dalbergia championii*

Nb = *Neba buxifolia*
Ca = *Carissa spinarum*
St = *Sapindus foliatus*


CEYLON
HEIGHTS IN METRES
SOIL MAP.
SOILS FROM IGNEOUS & GNEISSIC ROCKS
DRY LATERITIC LOAMS. I
WET LATERITIC LOAMS. II
NON-LATERITIC SANDY LOAMS. III
ULTRA WET LATERITIC LOAMS. IV
LIMESTONE SOILS
GREY LOAMS. V
RED MIOCENE LOAMS. VI
BLACK LOAMS. VII
RED LOAMS. VIII
BROWNISH LOAMS. IX
HUMIC SOILS
PATANA SOILS. X
KEKILLA SOILS. XI
PEATY SOILS. XII
PLEISTOCENE & SUB-RECENT
BROWN SANDY SOILS. XIII
WHITE SANDS. XIV
RECENT
ALLUVIAL XV.
DRY LATERITIC LOAMS
RED LOAMS
COLOMBO
BATTICALOA
HAMBANTOTA
GALLE
INDIAN OCEAN
REFERENCE
HEIGHTS IN METRES


CEYLON
HEIGHTS IN METRES
RAINFALL (ANN AV)
75-100
75-100
25-50"
50-75"
50"
75"
COLOMBO
100"
150-200
125-150
50-75
25-50
50"
100"
75"
50"
BATTICALOA
TRINCOMALEE
HEIGHTS IN METRES

was selected and a strip 6 metres wide by 45m. long was marked out and all the trees and shrubs plotted in their approximate positions. The heights of the trees had perforce to be estimated, and it was here that the experience of Messrs. Flemmich and Wyatt-Smith proved invaluable. It would obviously have been desirable to fell all the trees in each strip in order to measure crown height and diameter (cf. Richards *et al* 1939), but this was precluded by time considerations. The plotted strips are reproduced not only in schematic plan but also as profile side views, thus giving some idea of the density of the vegetation in a 6 metre band. The ground plan gives the positions of the trees and the size of the trunks with reasonable accuracy, but the profile view is only very approximate because the height measurements were obtained by eye, and there were no crown measurements nor estimates of the height of the first branch. A soil pit was dug in each strip and notes made of the profile whilst some soil samples were collected for subsequent analysis. At the same time one member of the party explored the surrounding forest, noting any additional species to be found and also securing some idea of its uniformity or otherwise.

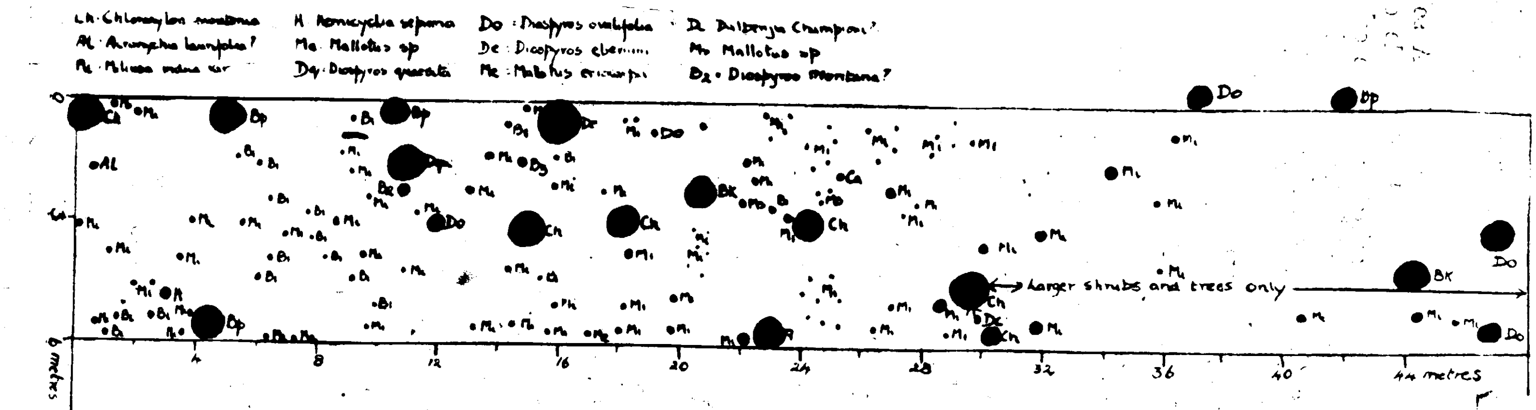
For convenience the general environmental features of each area are briefly summarised in the following table :

TABLE I.

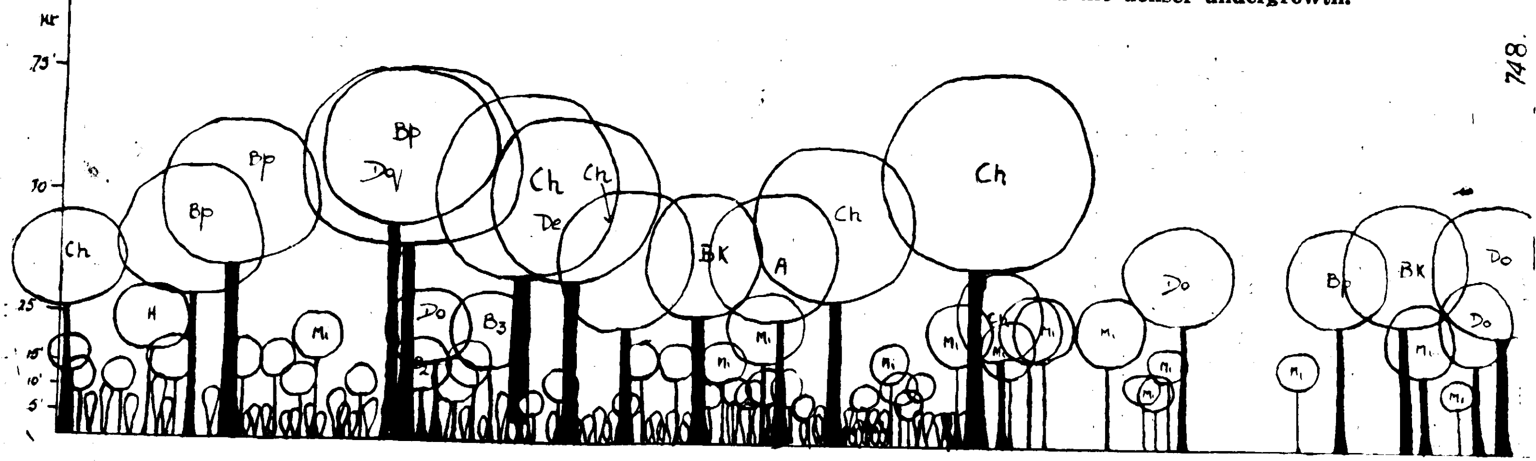
Principal environmental features of the areas selected (cf. map, plate 15).

Locality	Alt. in Ft.	Vegetation Type	Soil Type (from soil map)	Geological rock	Annual rainfall in inches
1. Deniyaya and Balutota	1000–2500	Western tropical Evergreen Forest	Lateritic red-yellow loams	Khondalite	100–150
2. Ratnapura	500–1000	Vitex-Wormia-Chaetocarpus Community	Lateritic red-yellow loams	Khondalite	150–200
3. Wellawaya	1000–1500	Moist Tropical Semi-Evergreen Forest	Lateritic red-yellow loams	Khondalite	75–100
4. Buttala	500	S. Tropical Moist Decid. Forest	Lateritic red-yellow loams	Gneiss	50–75
5. Hambantota	80	Manilkara Community Semi-desert scrub	Non-lateritic red, brown and yellow loams.	Gneiss	25–50
6. Komari	50	Manilkara-Hemicyclia Community: Beach scrub	White Sand	Gneiss	50–75
7. Puttalam	100	Manilkara Community Manilkara-Hemicyclia-Chloroxylon Community	White Sand	Post pliocene gravels	25–50
8. Vellankulam	50	Manilkara Community Acacia thogh scrub	Red Loam and Black Cotton Soil	Miocene Limestone	25–50
9. Nachchikuddi	20	Manilkara-Hemicyclia-Chloroxylon Community Zignoa Consociatis.	Red loam and White Sand	Miocene Limestone	25–50
10. Kandavalai	70	Manilkara-Hemicyclia-Chloroxylon Community	Lateritic red and brown loams	Sub-recent and Pleistocene	50–75
11. Oddisuddan	100	Do.	Lateritic red and brown loams	Gneiss	50–75
12. Mundel Lake	0	Suaeda and Salicornia Associations.	Alluvial	Sub-recent and Pleistocene	50–75
13. Viddataltivu	0	E. Mangrove Formation	Alluvial	Miocene Limestone	25–50
14. Batticaloa	0	Do.	Alluvial	Sub-recent and Pleistocene	50–75
15. Mahaweli Ganga	60	Damana Land	Lateritic red-yellow loams	Gneiss	50–75
16. Haputale	..	Cymbopogon-Imperata Association.	Dry patana Soil	Khondalite	75-100
17. Ambawela	..	Chrysopogon-Arundinella Association. Montane temperate Forest.	Non lateritic red and yellow earths and wet patana soil	Khondalite	75-100

BUTTALA



Mixed Deciduous Forest at Buttala. Note the lower height of trees as compared with Wellawaya, the closer spacing of the trees and the denser undergrowth.



H = *Hemicyclia sepiaria*
Ma = *Mallotus sp.*
Dq = *Diospyras quaesita*

Do = *Diospyros ovalifolia*
De = *Diaspyros ebenum*
Me = *Mallotus eriocarpa*

Dc = *Dalbergia Championii.*

A study of table 1 shows that there were considerable variations in the environment among the different localities, even in cases where the vegetation type belonged to the same formation (Nos. 5-11).

Vitex-Wormia-Chaetocarpus-Anisophyllea Community (*vide Fig. I, plate* 16 *and page* 290).

This type is represented by one example near Ratnapura, and its composition suggests that it is in fact the Myristica faciation of that community as described by Rosayro (1943). Most of the forest has been cleared and is now surrounded by tea and rubber plantations. The emergent trees form a more or less continuous canopy and this gives the roof of the forest an 'even' appearance as seen from the air. It is impossible to pick out any individual species amid the canopy but the greater height of trees along the water courses is noticeable. The tall dark-toned tree in such places is Hora (*Dipterocarpus zeylanicus*).

The soil, when examined, appeared to belong most nearly to the lateritic gravelly loams (Rosayro 1943) of the yellow earth type.

A_0 0-2 cms. Dark brown humus, loose, no stones, humus +++*, Water ++, numerous small roots.

A_1 2-6 cms. Yellow brown loam, loose, amorphous, no stones, humus+, water +, numerous large and small roots, pH 4.2, org. matter, 8.72%.

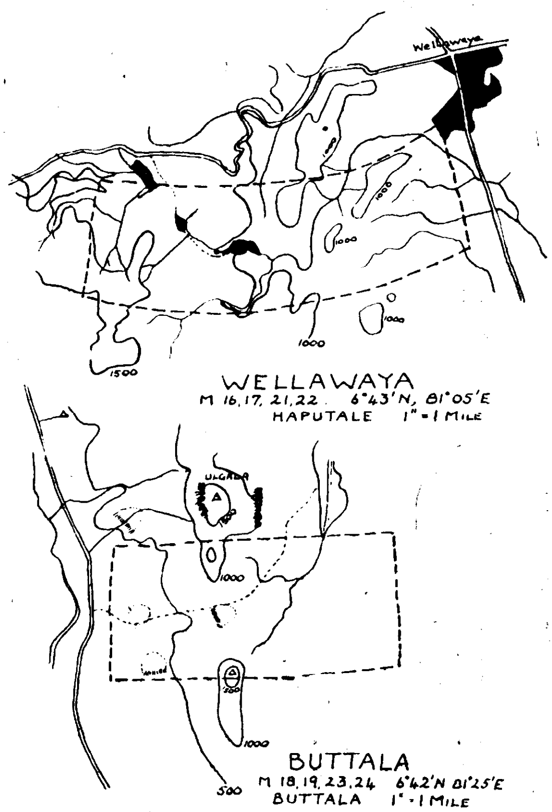
A_2 6-26 cms. Yellow brown clay loam, compact, amorphous, occasional small stones, water +, frequent big roots, pH 4. 5, org. matter 5.69%.

B_1 26-46 cms. Yellow brown loam, indurated, amorphous, frequent reddish pan concretions, water+, occasional small roots.

This type of forest occurs on several soil types so that it cannot be used as a soil indicator.

Moist Tropical Semi-evergreen Forest (*vide Fig. I, plate* 17, *and the text fig. in the next column.*)

Small representative areas of this type of forest still exist in the valleys around Wellawaya, but up on the slopes and tops of the hills one finds savannah†. In parts of the valleys the original forest has been cut down during the course of chena cultivation, and areas



Areas covered by air photographs at Wellawaya and Buttala. References to the respective ordnance survey sheets. Black areas are cultivated land.

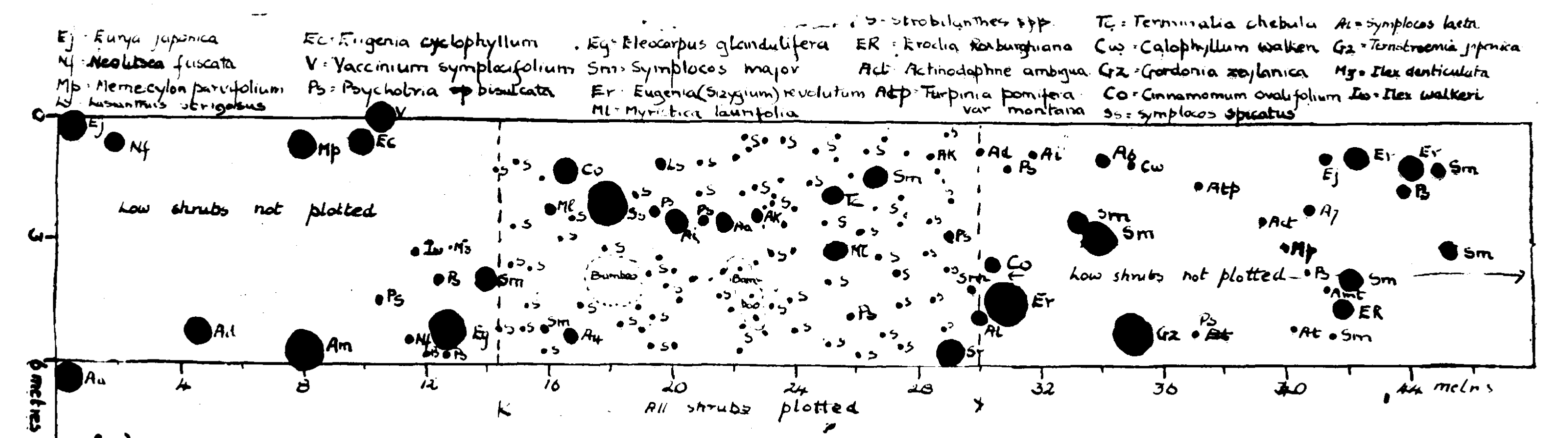
of secondary growth in varying stages of development are to be found (*cf. Fig.* I, *plate* 17). The forest is dark and even in tone with some large crowned trees, and shows up clearly from the savannah. There are no dominant species, and it is impossible to detect individual species within the canopy because there are no distinctly light-toned trees. It is, in fact, a forest type in which it is least likely that individual species will be identifiable from the air, even on large scale photographs. The presence of *Chloroxylon swietenia* (satin wood) suggests that this type of forest marks a transition from the wetter evergreen types to the dry evergreen type.

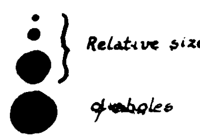
Other common trees in this type of fores are *Filicium decipiens.*, Thw., *Chukrasia tabularis* A. Juss, *Vitex altissma L*, *Chloroxylon swietenia* DC, *Gossampinus malabaricus* Merrill,

*Symbols used as in Clerke's Field Handbook (1940).

†Savannah is here taken to represent a grassland with a very open canopy of trees.

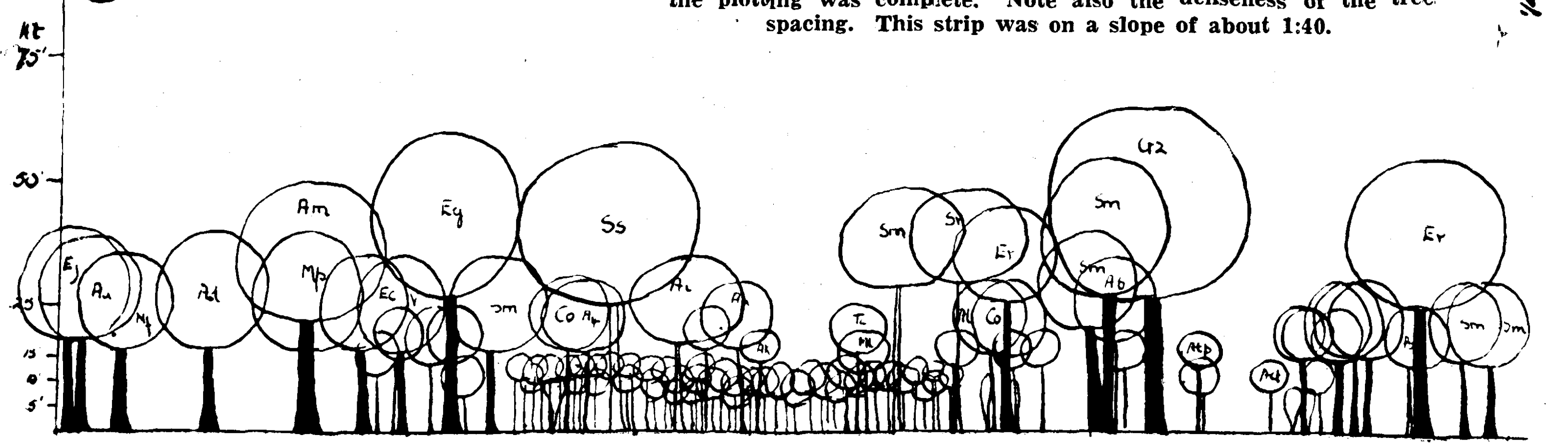
AMBAWELA



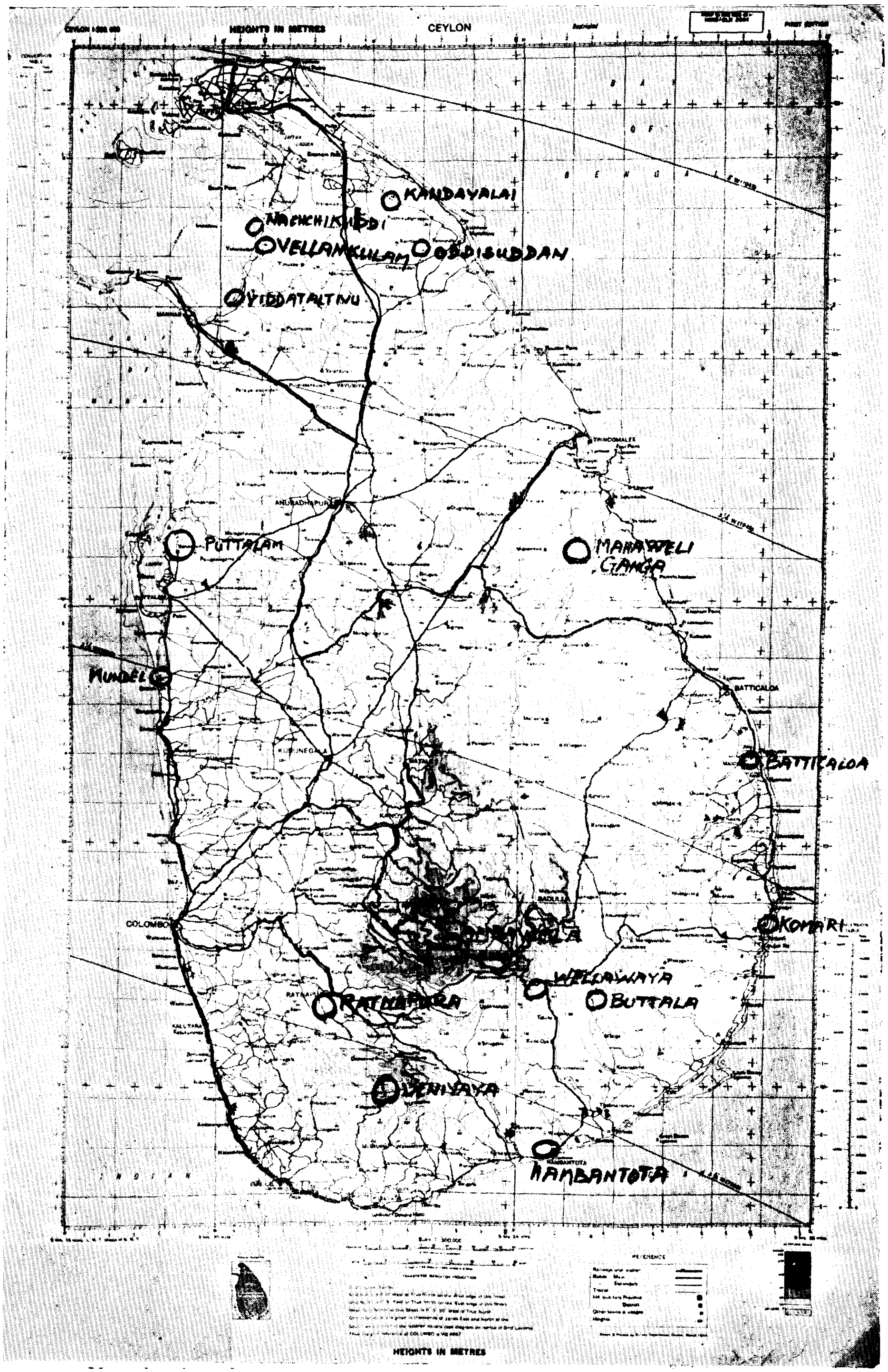


6.8.48

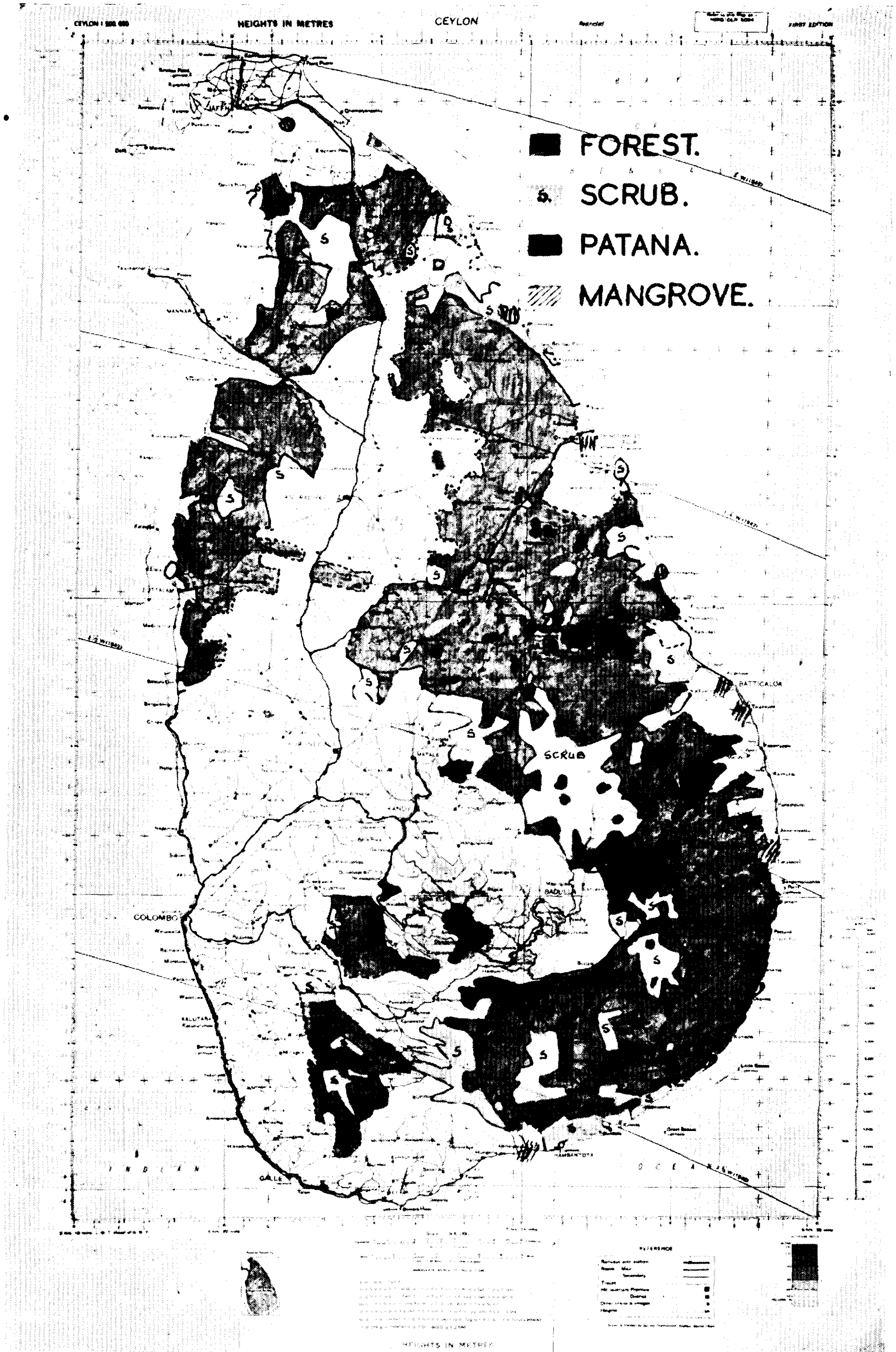
Montane Subtropical Evergreen Forest at Ambawela. Note the extreme density of the shrub layer in the middle section where the plotting was complete. Note also the denseness of the tree spacing. This strip was on a slope of about 1:40.



S = *Srtobilanthes spp.*	Tc = *Terminalia chebula*	Ai = *Symplocos laeta*	Ej = *Eurya japonica*
Ec = *Eugenia cyclophyllum*	Eg = *Eleocarpus glandulifera*	Er = *Erodia Roxburghiana*	Cw = *Calophyllum walkeri*
G2 = *Ternstroemia japonica*	Ni = *Neolitsea fuscata*	V = *Vaccinium symplocifolium*	Sm = *Symplocos major*
Act = *Actinodaphne ambigua*	Gz = *Gordonia zeylanica*	Mz = *Ilex denticulata*	Mp = *Memecylon parvifolium*
Ps = *Psychotria bisulcata*	Er = *Eugenia (Sizygium) revolutum*	Atp= *Turpinia pomifera Var. montana*	Co = *Cinnamomum ovalifolium*
Iw = *Ilex walkeri*	Ly = *Lasianthus strigosus*		Ml = *Myristica laurifolia*
			Ss = *Symplocos spicatus*



CEYLON
HEIGHTS IN METRES
KANDAYALAI
VELLANKULAM
ODDISUDDAN
PUTTALAM
MAHAWELI
GANGA
TRINCOMALEE
ANURADHAPURA
MUNDEL
BATTICALOA
KOMARI
COLOMBO
WELLAWAYA
BUTTALA
HAMBANTOTA
HEIGHTS IN METRES


CEYLON
HEIGHTS IN METRES
FIRST EDITION
FOREST.
SCRUB.
PATANA.
MANGROVE.
SCRUB
BATTICALOA
COLOMBO
KALUTARA
GALLE
HAMBANTOTA
BADULLA
PUTTALAM
MANNAR
JAFFNA
INDIAN
OCEAN
REFERENCE
HEIGHTS IN METRES

Garcinia cambogia Desv., *Sterculia* sp., *Entada puasaetha* DC, (climber), *Hydnocarpus Wightii.*

The soils of forest and savannah did not differ fundamentally, except that the latter showed evidence of periodic fires in the fragments of charcoal that could be found in the surface layers. The soil sample was collected from a moderate slope with good drainage, small micro-undulations and a N. E. aspect: rain was falling at the time of sampling.

A_1 0-2 cms. Dark brown loam, loose-friable, amorphous, no stones or animals, humus ++−+++, water +, numerous small roots, org. matter 4.69%.

A_2 2-25 cms. Yellow brown loam, loose-compact, amorphous, occasional large lumps of khondalite, humus +, water+, numerous large and small roots.

C_1 25-50 cms. Reddish-brown clay loam, indurated, occasional large lumps of khondalite, water+, occasional small roots.

C_2 50-92.5, cms. Crystalline khondalite with bands of reddish clay soil, laminated, indurated, water+, occasional small roots.

C 92.5+ cms. Decomposing parent rock of crystalline khondalite.

Genetically this soil type seems most closely allied to the residual non-gravelly loams of the non-lateritic yellow earths. It does not, in fact, appear to differ very materially from type II as described by Rosayro (1942).

Tropical Savannah formation (Fig. 1, plate 17.)

Isolated examples of this vegetation occur at Wellawaya, and they possess a very characteristic appearance from the air. The principal community is a Careya-Anogeissus-Cymbopogon-Imperata association which is maintained by periodic burning. There seems little doubt that this type of vegetation is the outcome of burning and grazing, the burning taking place at long enough intervals to enable the thick-barked trees to grow sufficiently tall to escape serious damage. From the air the trees in May appear a much lighter green, as compared with those of the nearby forest, a fact that can be associated with the semi-deciduous habit and the development of new foliage about this time. The trees 'tone in' with the grass ground cover so that it is very difficult to determine the size and shape of the crowns, and this renders specific identification impossible. Their colour at a later stage in the year is darker and the distinction from the wet forest is far less marked. In the same photograph can also be seen various stages in secondary growth after *chena* cultivation: this is characterised by the evenness and denseness of its canopy.

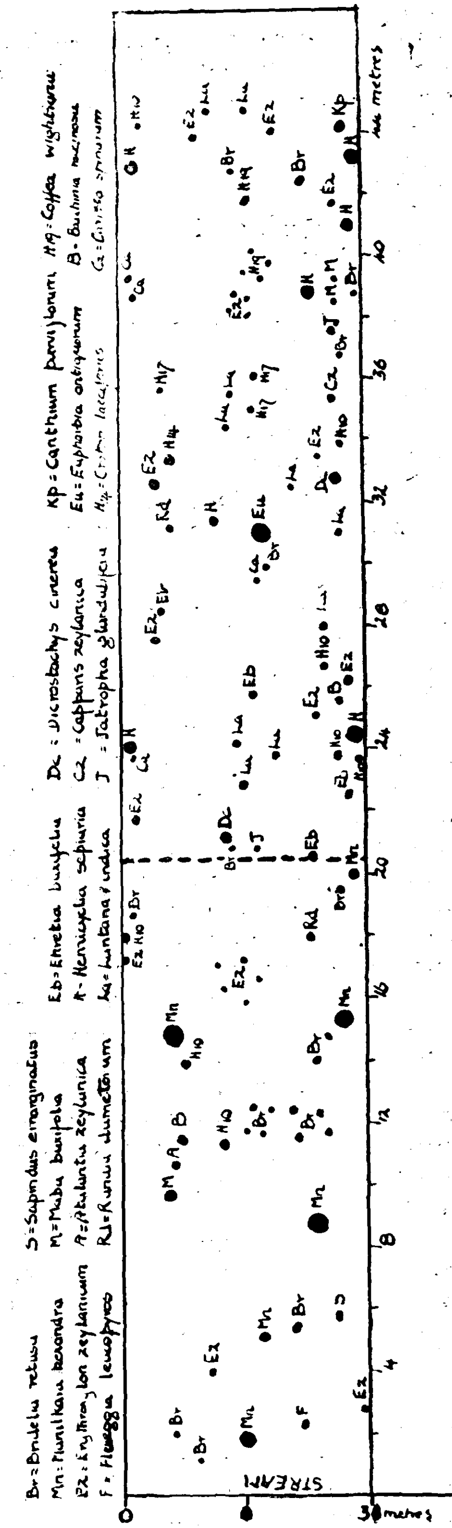
South Tropical Moist Deciduous Forest (vide text fig. on page 295; Fig. II., plate 17; and page 294).

Twelve miles from Wellawaya, where there is a lower annual rainfall, the forest vegetation changes sufficiently to be regarded as representative of quite a different type. A comparison of the photographs of plate 17 is sufficient to show the differences as seen from the air. At Buttala the forest is semi-deciduous and the colour of the canopy is more varied and rather lighter in tone. The trees of the emergent layer are more conspicuous than at Wellawaya, whilst there is more variety in crown size, though the trees of the dominant layer seem on the whole to have smaller crowns. Close inspection of the photograph leads one to suggest that at least two tree species (one light and one dark toned) are sufficiently distinct to be identifiable from the air. Towards the left the second storey is clearly visible with the isolated crowns of the taller trees of the top storey arising above it at intervals. At Wellawaya the crowns of the trees in the first storey form a more or less unbroken canopy. In many cases the lighter toned trees are *Chloroxylon swietenia* (satin wood), whilst some of the darker toned trees are species of Diospyros. Ecologically this type of forest indicates drier conditions. Apart from the difference in composition, as compared with Wellawaya (*cf. figs. on pages* 292 *and* 294) the spacing of the trees is much closer, the undergrowth is somewhat denser* and the height of the trees is less. This latter character must be related to the more arid conditions.

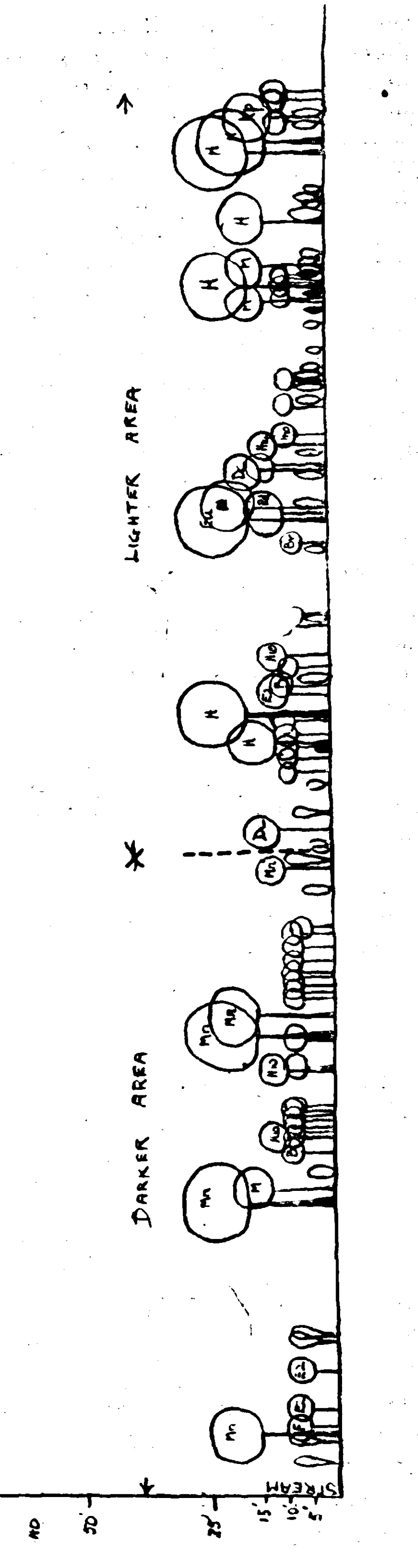
The map of the area in the text fig. given on p. 295 indicates that two tanks existed at one time, but there was no clear evidence of

*This is a feature that requires further investigation because normally a denser undergrowth is associated with a more open canopy. Closer spacing of trees could be offset by species with more open crowns, thus permitting light to penetrate.

HAMBANTOTA



Dry evergreen forest at Hambantota. The forest was so dense that only 3 metres were used for the width of the strip. Note the absence of any large trees.



these from the air. During the course of the ground survey we encountered one of these tanks and it was completely overgrown by forest, which appeared to be no different in composition from the surrounding vegetation. The soil was very much more sandy than elsewhere, due to wash from rain-water run-off, but even so the presence of the old *bunds* probably ensures that during the wet season this tank area remains rather wetter than the surrounding forest soil. The absence from the air of any indication of these local conditions in soil and water is a striking feature.

The soil in the forest is a light loam, extremely compact in the dry season. There was no evidence of gleying so that the drainage must be good. The sampling site was flat and there was some rain just before the sample was taken.

A_1 0-2.5 cms. Light brown, sandy loam, loose, amorphous, no stones, humus++,°° small roots, transition to next zone sharp, H_2O+.

A 2·5-45 cms. Yellow brown, compact loam, no stones, humus °° large and small roots, transition to next zone wavy and indefinite. H_2O+.

C_1 45- cms. Browny-red, very compact, indurated, heavy loam, occasional small roots, no stones or animals. H_2O+.

ANALYSES

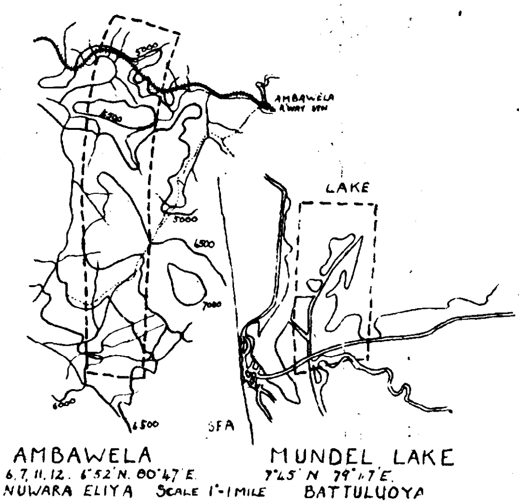
	Stone and Gravel	Coarse sand	Fine sand	Silt	Clay	H_2O	pH	Carbon	Org. matter
A_1	1.0	44.5	30.3	5.9	15.9	2.1	7.0	4.78	8.24
A_2	4.5	31.6	29.9	1.0	1.0	2.0	6.4	0.90	1.55
C	—	—	—	—	—	—	6.4	0.6	1.13

It will be seen that the principal difference between the A_1 and A_2 horizons is in the relative proportions of clay and silt. The higher proportion of clay in the A_2 layer is responsible for its extreme hardness under dry conditions.

The profile suggests that this soil is most closely akin to the non-lateritic alluvial yellow earth of the wet zone (Rosayro 1943).

Montane Temperate Forest (*vide text fig. in the next column and page* 296)

A very good example of this forest type can be seen in the mountains around Ambawela, and an examination of the photographs shows that it is quite distinct in appearance from the forests already considered, with the possible exception perhaps of the wet evergreen forests



Areas covered by air photographs at Ambawela and Mundel Lake. References to Ordnance survey sheet and grid reference.

of S. W. Ceylon. The velvety appearance, however, does afford some resemblance to mangrove swamp (*cf. fig. II, plate* 22). Other features of this type of forest, as seen from the air, are the small crowns of the trees, their low stature (from shadows) and the incompleteness of the canopy, so that at times the shrubby, undergrowth is evident through the gaps. The very striking difference in tone on either side of the ridges is a light effect and does not indicate a change in forest composition. In view of the great diversity of species in the top storey the forest can perhaps best be described as a southern montane temperate community.

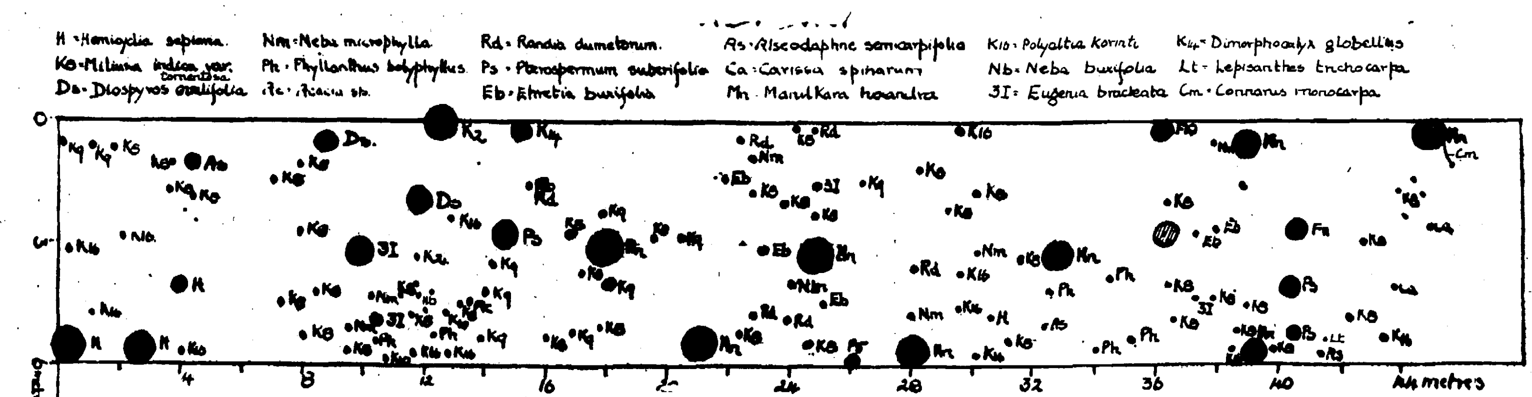
Away from the paths the ground flora in this type of forest is scanty and consists mainly of mosses (a), *Indo-calamus debilis* (lf) and *Selaginella* sp. Near the paths where more light is available the vegetation is abundant and a considerable number of species are present.

Details of the soil are given below. It is a typical non-lateritic yellow earth and would appear to be closely allied to the residual gravelly loams described by Rosayro (1943).

Slope considerable, aspect N.E., drainage good, continuously wet.

A_0 0-0.5 cm. Raw humus, transition indefinite.

KOMARI



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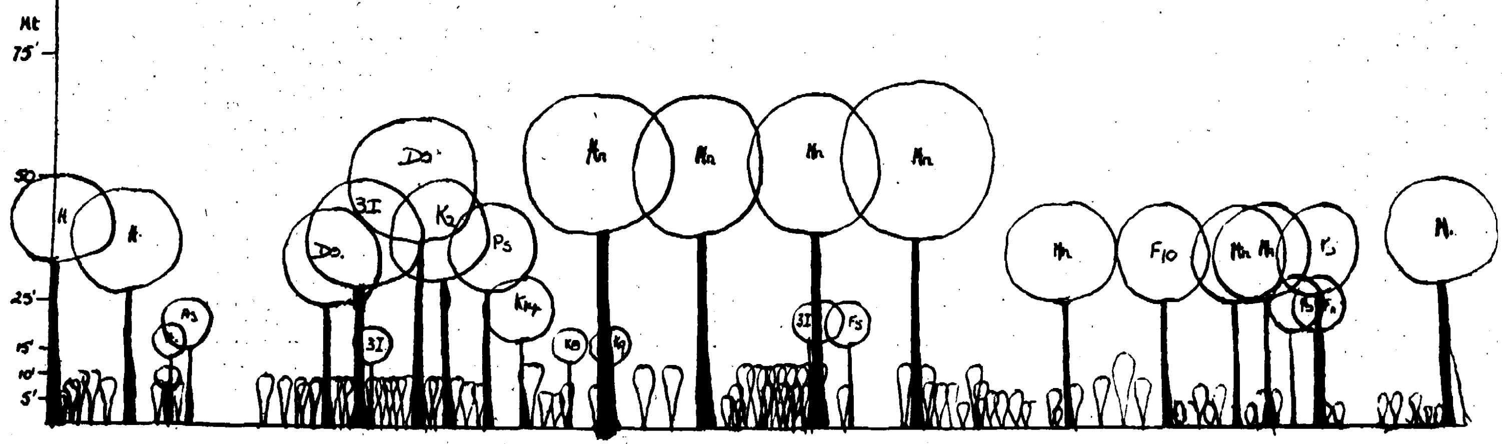
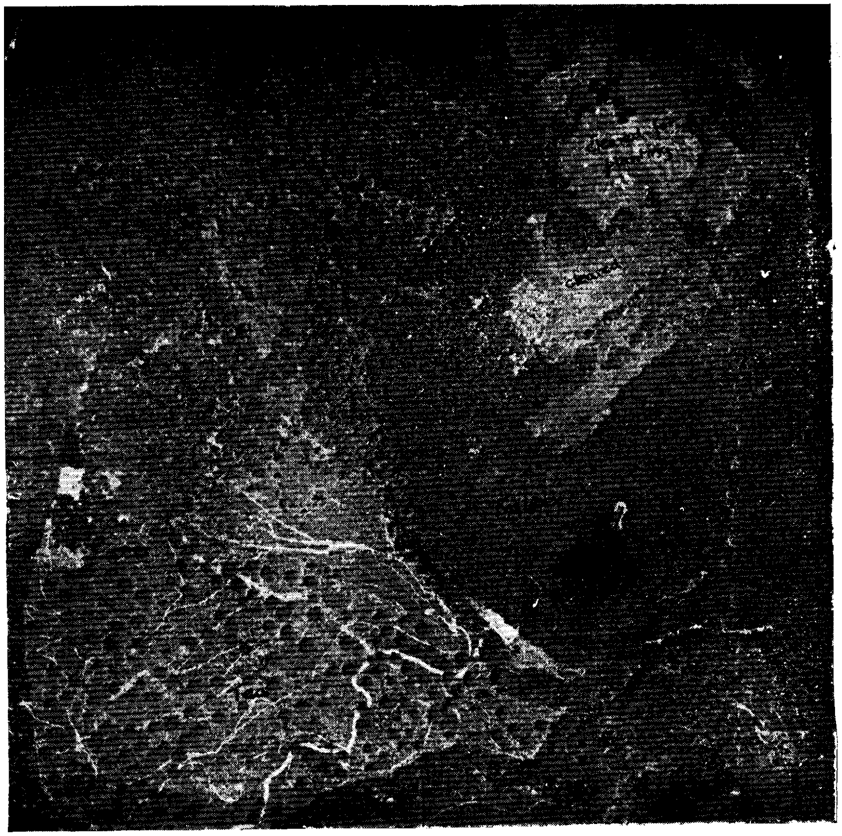
Dry evergreen forest at Komari. Compare the height of the trees with those at Hambantota (page 298).



H = *Hemicyclia sepiaria*
K16 = *Polyaltia korinti*
Ps = *Pterospermum suberifolia*
Ds = *Diospuros ovalifolia*
31 = *Eugenia bracteata*
Nm = *Neba microphylla*
K14 = *Dimoiphocalyx globellus*
Ca = *Carissa spinarum*
Ac = *Acacia sp.*
Cm = *Connarus monocarpa*
Rd = *Randia dumetorum*
Ke = *Miliusa indica var.*
Nb = *Neba buxifolia tomentosa*
Eb = *Ehretia buxifolia*
As = *Alseodaphne semicarpifolia*
Ph = *Phyllanthus polyphyllus*
Lt = *Lepisanthes trichocarpa*
Mn = *Manilkara hexandra*

Fig. I



Forest at Ratnapura

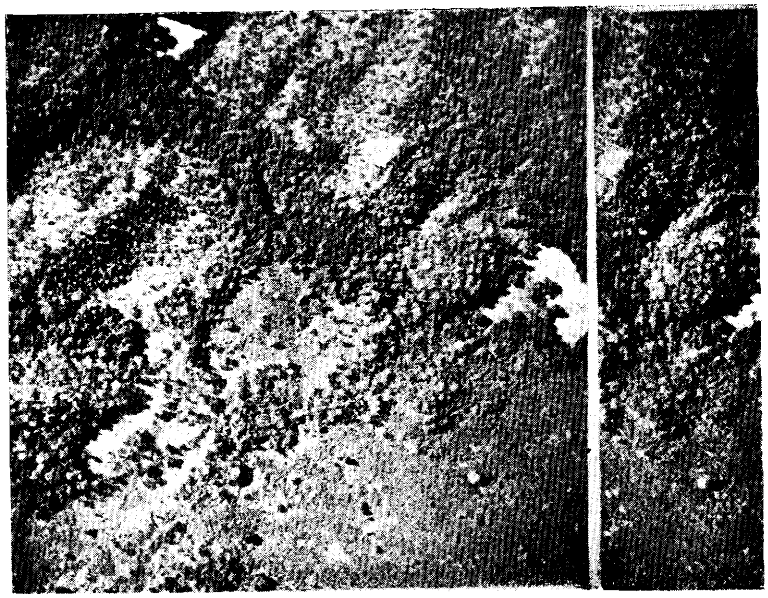
Vitex—Wormia—Chaetocarpus—Anisophyllea community (upper left) Tea and Rubber plantations also shown. Note the even top to the canopy, and the relatively light tone. The large trees along the stream were many of them Hora **(Dipterocarpus zeylanicus)**. (Scale 1/9000, green filter, May, **1945)**.

Fig. II

Hambantota

Tropical dry evergreen forest. Note the dark tone of the Manilkara community (M) in contrast to the thorn scrub (T). The arrow indicates individual trees of Manilkara with their compact crowns. Compare this with Fig. II, plate 18, showing that the tone differences appear to be more pronounced with the green filter than with the yellow. (Scale 1/9000, green filter, May, 1945).

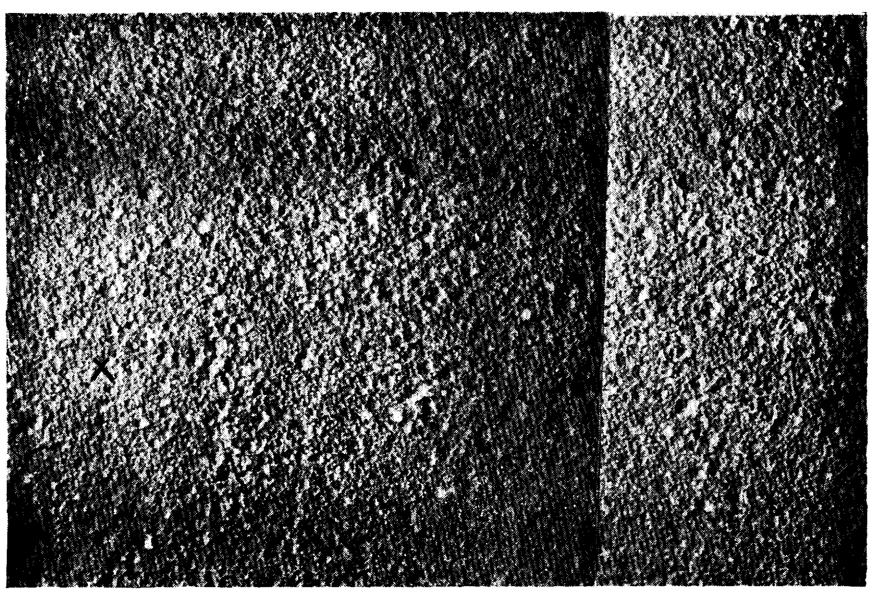
Fig. I



Wellawaya

Moist tropical semi-evergreen forest with savannah and stages in secondary growth after chena cultivation. The forest persists in the valleys only and is generally dark-toned from the evergreen trees. In this type of forest it is not easy to pick out individual species. In the savannah the crowns of the trees merge with the grassland below and species identification is impossible. Note the restriction of savannah to the hill sides. In the secondary growth the canopy is not high and is very even. The isolated light-toned tree near the bottom right is probably **Chloroxylon swietenia.** (Scale 1/7200, yellow filter, Sept., 1945).

Fig. II



Buttala

South tropical moist deciduous forest. Note that the tall trees stand out well above the main canopy and that they have large crowns. The trees of the canopy have small crowns. One or two of the trees have a characteristic crown (e.g., the very light-toned tree marked by arrows) and would seem to be identifiable. The tank was sited approximately at the point marked X. (Scale 1/7200, yellow filter, Sept., 1945).

A_0 5-12.5 cm. Yellow brown, loose clay loam, friable, occasional medium stones, °° large and small roots, worms present, humus +++, H_2O+—++ transition indefinite.

A_2 12.5-46 cms. Browny yellow clay loam, loose, occasional small stones, °° small roots, occasional large roots, worms, humus +, H_2O + — ++ transition indefinite.

B_1 46-70 cms. Puce, compact, clay with some silt, small stones frequent, small roots (f), large (r), humus ++, H_2O ++, transition indefinite.

B_2 70 cms +, Ochre, compact, fine clay with much silt, no stones, small roots (o-f), large (r), H_2O +++.

Tropical Dry Evergreen Forest (vide Fig. II, plate 16, *and Fig. II, plate* 21)

This type covers the major part of Ceylon that is still under forest. It is found from the south up the whole of the eastern province and thence across most of the northern province, excluding the Jaffna peninsula. From our studies it seems likely that it can be regarded as composed of three or four associations or consociations. A more detailed investigation may increase this number. Some form of this forest type was found at Hambantota, Komari, Puttalam, Vellankulam, Nachchikuddi, Kandadalai and Oddisuddan. Before describing any of these areas in detail a summary of the vegetation recorded from the sample strips is given in table 2, on page 303.

TABLE 3.

Density (D) and av. ht. in ft, of vegetation in the different communities of the Dry Evergreen Forest.
Density expressed as numbers per 120 sq. metres.

	Hambantota	Vellankulam	Komari	Puttalam	Nachchikuddi	Kandavalai
Top storey D.	10	5	8	2	2	4
Ht.	25—30 ft.	25—30 ft.	45—70 ft.	45—50 ft.	40—50 ft.	55—65 ft.
Second storey D.	Absent	Absent	6	9	3	15
Ht.			20—30ft.	25—35 ft.	22—30 ft.	25—35 ft.
Shrubs D.	66	28	45	31	38	65
Ht.	5—20 ft.	5—20 ft.	5—15 ft.	5—20 ft.	5—20 ft.	5—20 ft.

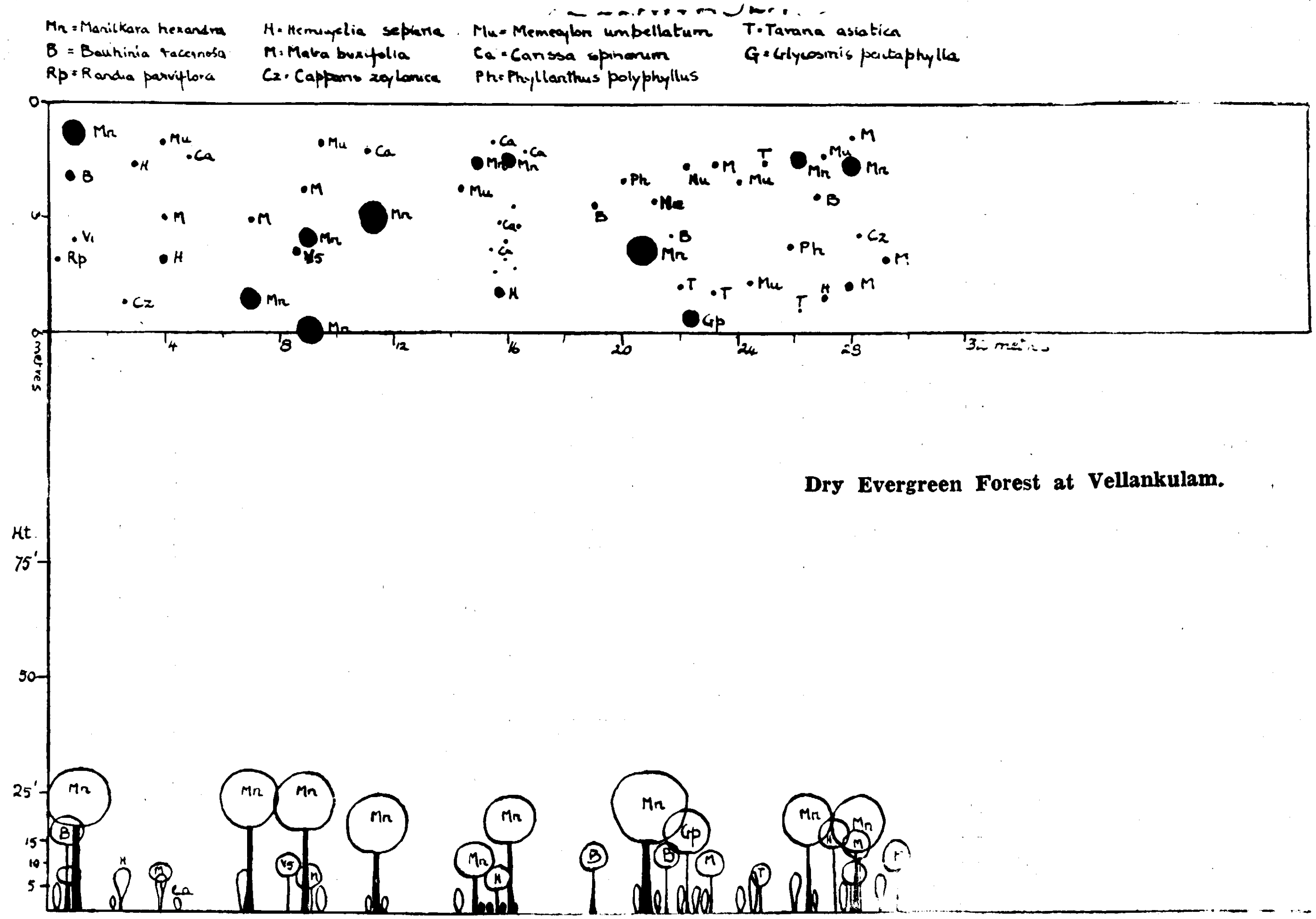
A study of table 2 (page 303) and table 3 above strongly suggests that the Tropical Dry Evergreen Forests of Ceylon can be subdivided into at least four distinct communities as follows :—

1 *Manilkara* (*Mimusops*) *hexandra* community (*Fig. II, plate* 16 *and Fig. I, plate* 19).

This is represented by parts of the forests at Hambantota, Puttalam (area B) and Vellankulam. It is characterised by abundant Manilkara in the dominant storey with a number of other species in the shrub layer, *Bridelia retusa* Spr. being dominant at Hambantota and at Vellankulam. At these two places the climate is very arid and the trees do not grow to any great height : as a result there is no distinct second storey of trees. The distribution of the community in these two areas is of considerable interest. At Hambantota it appears to be confined to wetter places (*Fig. II, plate* 16 *and page* 298), *e.g.* along the banks of irrigation canals, in the beds of ephemeral streams, or in the lower lying areas where the water table rises nearer the surface in the rainy season. In such places the soil shows strong evidence of gleying not far below the surface. At Vellankulam (*Fig. I, plate* 20) the community forms a fringe to the forest where it adjoins the Acacia scrub. The environment here will be wetter than in the rest of the forest, which grows on a cap of red loam, but at the same time it will not be subject to the waterlogging that probably occurs seasonally in the Acacia scrub. Pure Manilkara when growing in arid areas therefore seems to be an indicator of rather wetter soil conditions. A very slight rise, 25—50 ft., in elevation appears to be sufficient to bring about the necessary soil water changes so that Manilkara no longer is a pure dominant but is associated with other species, some of which are partly or wholly deciduous. It may be suggested that the greater dominance of Manilkara in the wetter areas can perhaps be correlated with its seeding

748:7

VELLANKULAM



Dry Evergreen Forest at Vellankulam.

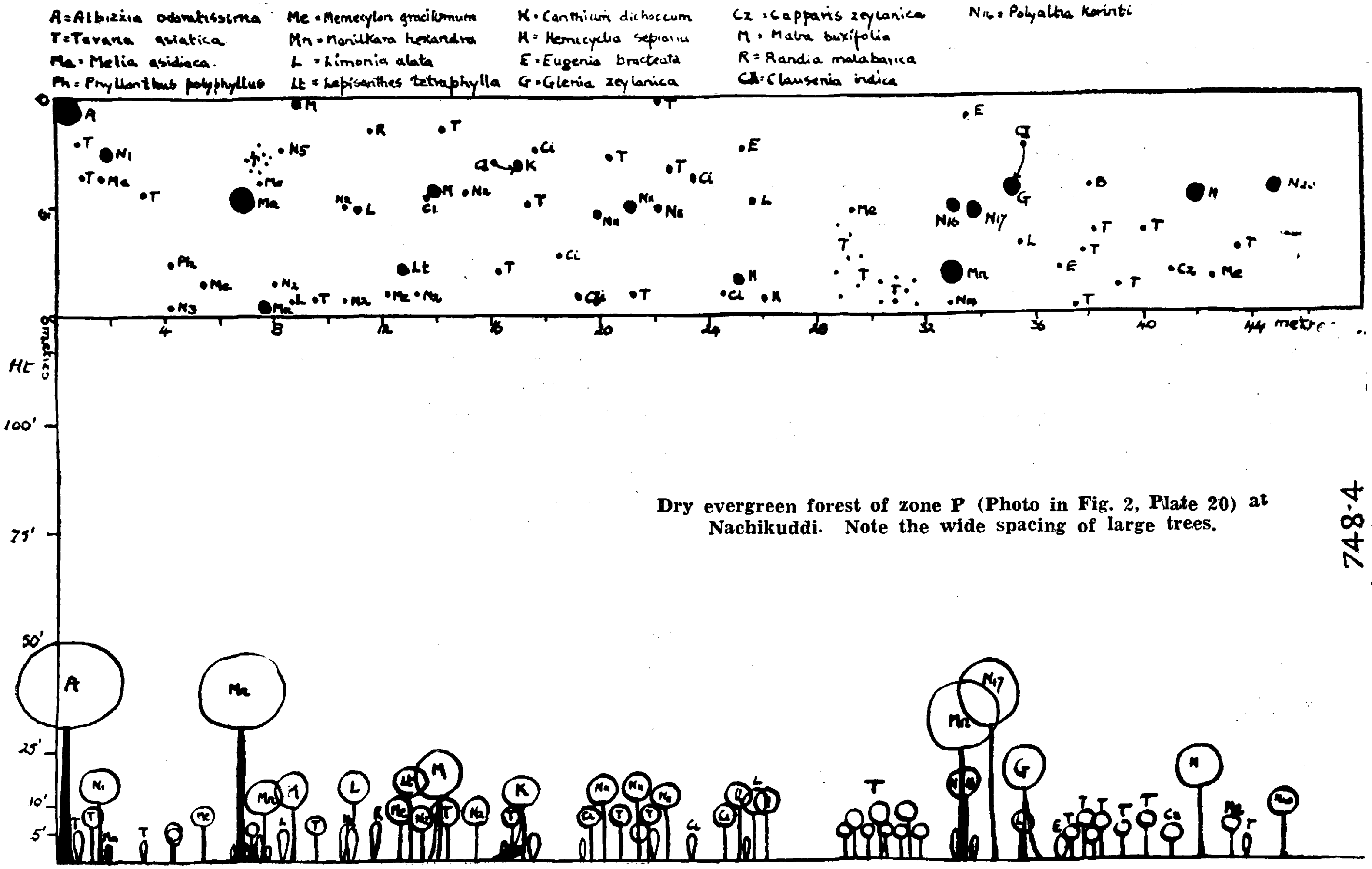
Mn = *Manilkara hexandra*
B = *Bauhinia racemosa*
Rp = *Randia parviflora*
H = *Hemicyclia sepiaria*
M = *Maba buxifolia*
Cz = *Capparis zeylanica*
Mu = *Memecylon umbellatum*
Ca = *Carissa spinarum*
Ph = *Phyllanthus polyphyllus*
T = *Tarana asiatica*
G = *Glycosmis pentaphylla*

TABLE 2.—*Composition of Dry Evergreen Forest types studied in the Survey.**

	HAMBANTOTA	VELLANKULAM	KOMARI	PUTTALAM	NACHCHIKUDDI	VANDAKALAI & ODDISUDDAN
	Manilkara hexandra Dub.	*M. hexandra* Dub.	*M. hexandra* Dub. *Eugenia bracteata* Roxb. *Hemicyclia sepiaria* W.& A. *Diospyros ovalifolia* Wight *Pterospermum suberifolium* Lam.	*M. hexandra* Dub. *Chloroxylon swietenia* DC.	*M. hexandra* Dub. *Albizzia odoratissima* Benth. Unidentified	*M. hexandra* Dub. *Chloroxylon swietenia* DC. *Eugenia bracteata* Roxb. *Vitex* sp.
	Absent	Absent	*Ehretia buxifolia* Roxb. *Hemicyclia sepiaria* W.& A. *Alseodphne.* *Semicarpifolia* Nees *Cleistanthus pallidus* Muell *Pterospermum suberifolium* Lam. *Engenia bracteata* Roxb. *Miliusa indica* Lesch. var. *tomentosa* Thw. *Dimorphocalyx globellus* Thw. *Memecylon umbellatum* Burm.	*Cassipourea zeylanica* (Gardn.) Alst. *Diospyros ebenum* Koenig P_1 Unidentified.	*M. hexandra* Dub. *Hemicyclia sepiaria* W.&A. *Glenie zeylanica* Hook. *Polyalthia korinti* B.&Hk.	*Hemicyclia sepiaria* W.&A. *Eugenia bracteata* Roxb. *Walsura piscidia* Roxb. *Hesperettinsa alata* (W.&A.) Alst. *Alseodaphne semicarpifolia* Nees *Chloroxylon swietenia* DC. *Diospyros ebenum* Koenig *Cassia fistula* L.
	Manilkara hexandra Dub. *Bridelia retusa* Spr. *Flueggia leucopyros* Willd. *Erythroxylon zeylanicum* O. E. Schulz *Sapindus emarginatus* Vahl. *Atalantia zeylanica* Oliv. *Randia dumetorum* Lam. Unidentified *Tarenna asiatica* (L) O. Kuntze	*Bauhinia racemosa* Lam. *Carissa spinarum* L. *Hemicyclia sepiaria* W. & A. *Memecylon umbellatum* Burm. *Polyalthia korinti* B. & Hk. *Maba buxifolia* Pers. *Phyllanthus polyphyllus* Willd. *Glycosmis pentaphylla* Corr. *Tarenna asiatica*(L)O.Kuntz *Randia parviflora* Lam. *Capparis zeylanica* L. *Randia dumetorum* Lam.	*Rinore avirgata* (Hodel & Thw.) O. Kuntze *Tragia hispida* Willd. *Ixora tchwaitesii* Hk. *Pilea microphylla* Liebm. *Connarus monocarpus* L. *Glycosmis mauritana* *Memecylon umbellatum* Burm. *Polyalthia korinti* B. & Hk. *Maba buxifolia* Pers. *Lepisanthes trichocarpa* (Thw.) Alst. *Ehretia laevis* Roxb.	*Ochna wightiana* Wall. *Memecylon gracillimum* Alst. *Tarenna asiatica* (L) O. Kuntze *Mischodon zeylanicum* Thw. *Diospyros ebenum* Koenig. *Capparis zeylanica* L. *Phyllantinus polyphyllus* Willd. *Hemicyclia sepiaria* W.&A. *Hugonia mystax* L. *Strychnos nux-vomica* L. *Ehretia buxifolia* Roxb. *Maba buxifolia* Pers.	*Tarenna asiatica* (L) O. Kuntze *Melia azadirachta* L. *Clausena indica* Oliv. *Carissa spinarum* L. *Memecylon umbellatum* Burm. *Randia malabarica* Lam. *Maba buxifolia* Pers. *Capparis zeylanica* L. *Eugenia bracteata* Roxb. *Canthium dicoccum* Merr. *Lepisanthe tetraphylla* Radlk. *Hesperetlinsa alata* (W.&A.) Alst. *Memecylon gracillimum* Alst. *Phyllanthus polyphyllus* Willd. *Polyalthia korinti* B.&Hk.	*Maba buxifolia* Pers. *Mamecylon gracillimum* Alst. *Pterospermum canescens* Roxb. *Phyllantinus polyphyllus* Willd. *Strychnos nux-vomica* L. Derris sp. *Polyalthia korinti* B.&Hk. *Carissa spinarum* L. *Neolitsea involucrata* Alst. *Randia dumetorum* Lam. *Tarenna asiatica* (L) O. Kuntze *Hemicyclia sepiaria* W.&A. *Walsura piscidia* Roxb. *Ixora parviflora* Vahl var. *zeylanica.*
Ground flora	*Bryophyllum calycinum* Salisb. *Carissa spinarum* L. *Strobilanthes stenodon* Clarke. *Cyrtococcum trigonum* (Retz) A. Camus *Bridelia retusa* Spr. 50-70%	Not studied	*Scleria lithosperma* Sw. *Isachne kunthiana* Wight *Carissa spinarum* L. *Adiantum caudatum* L. 80-90%	None	*Carissa spinarum* L. Low %	*Isachne kunthiana* Wight 15%

748·4

NACHCHIKUDDI



Dry evergreen forest of zone P (Photo in Fig. 2, Plate 20) at Nachikuddi. Note the wide spacing of large trees.

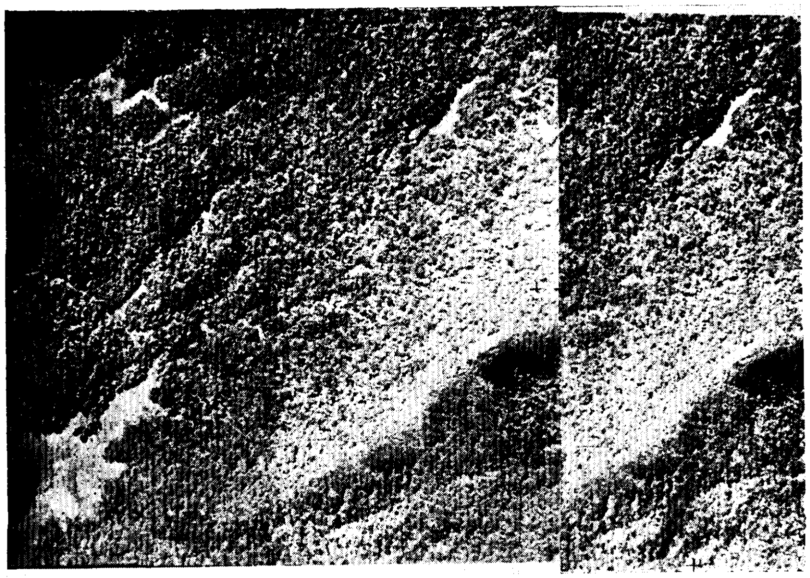
A = *Albizzia odoratissima*
N14 = *Polyaltia korinti*
Ma = *Melia asidiaca*
Ph = *Phyllanthus polyphyllus*
M = *Maba buxifolia*

Me = *Memecylon gracillumum*
T = *Tarana asiatica*
L = *Limonia alata*
Lt = *Lepisanthes tetraphylla*

K = *Carithium dichoccum*
Mn = *Manilkara hexandra*
E = *Eugnia bracacteata*
G = *Glenia seyanica*

C = *Capparis zeylanica*
H = *Hemicylia sepiaria*
R = *Randia malabarica*
Ci = *Clusenia indica*

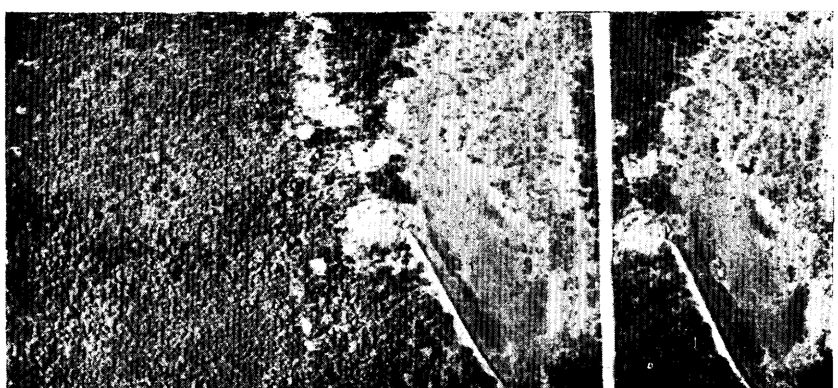
Fig. I



Ambawela

Montane temperate forest. Note the small crowns of the trees and the low height (seen at gaps). Note the general 'velvety' appearance except on one side of the ridge where the sun shines directly on the trees. The tall shrubby undergrowth can be seen in many places as the canopy is incomplete. (Scale 1/9000, green filter, July, 1945).

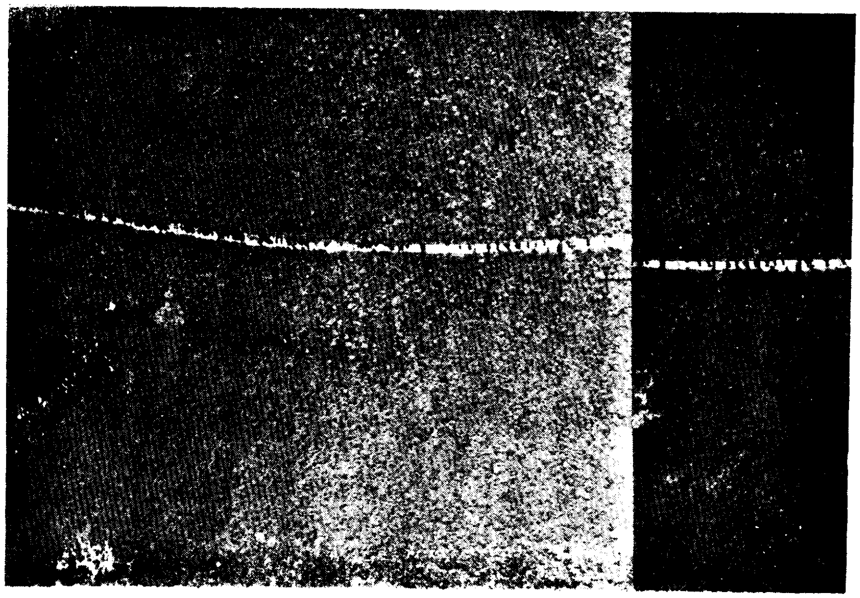
Fig. II



Hambantota (= Part of Fig. II, plate 16)

Tropical dry evergreen forest. The Manilkara is not so distinct here but they stand out in the thorn scrub (T) by virtue of their larger size. The rectangle marks the site of the strip. (Scale 1/7200, yellow filter, Sept., 1945).

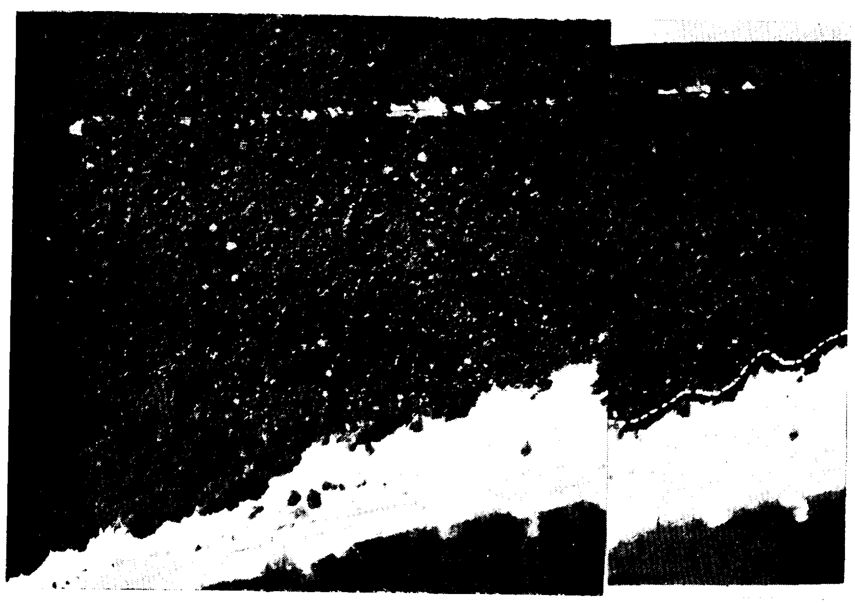
Fig. I



Puttalam

Tropical dry evergreen forest. Manilkara community (B) and Manilkara—Chloroxylon—Albizzia community (A). In the former note the dark even tone with large trees of Manilkara arising above the general canopy and characterised by more or less compact crowns. Zone A differs photographically in the presence of light-toned trees (Chloroxylon, Albizzia) arising above the general canopy. (Scale 1/9000, green filter, May, 1945).

Fig. II



Komari

Tropical dry evergreen forest (Manilkara-Hemicyclia community). The community is very flecked in tone, the small light-toned trees of the 2nd storey probably being Hemicyclia. Compared with the forest at Butala there is more flecking in the canopy and the crowns of the tallest trees are rather broader. The dotted line marks the boundary between beach scrub and forest. (Scale 1/7200, green filter, August, 1945).

habits. Normally it fruits in the dry season in Ceylon, but the seeds require water for germination and so seedlings are not common*. In the damper areas there will be a greater opportunity for successful germination and hence increasing dominance.

At Puttalam (*Fig. I, plate* 19) the climate is not so arid as the annual rainfall is double that of Vellankulam. Here the Manilkara consociation (B) occurs at the higher elevation but again on a reddish sandy loam of the non-lateritic dry zone forest type. Unfortunately time did not permit a soil pit to be dug in order to ascertain if a pan layer occurs. The other zone (A) at Puttalam is on a pale yellowish sandy loam belonging to the white sand group. Under the wetter conditions of Puttalam satinwood competes well and the pure Manilkara seems to be restricted to the drier soil zone. The evidence is by no means conclusive, but the behaviour of Manilkara under different climatic and soil conditions seems to demand further study.

A comparison of this type of community with the other three types will be made at the end of the section.

The soil at Hambantota was examined at a place where the ground was flat. There had been no rain previous to sampling. The presence of a gleyed B_2 horizon suggests that this soil belongs to the Ground Water† group and is an example of the forest gley type. (This type has so far not been recognised from Ceylon.)

A_1 0—15 cms. Yellow brown sandy loam; compact, no stones and no animals. Numerous fine roots, hums +, water+. The transition to the next layer was indefinite. (2″).
An interesting feature was the presence of charcoal debris at 7.5 cms. below the surface. This suggests that at some previous period this forest has been subject to *Chena* cultivation. If this time were known from historical records a figure could then be calculated for the rate of soil accretion.

B_1 15—47.5 cms. More brown in colour with occasional patches of reddish pan material: very compact to indurated. No stones, large and fine roots, transtion to next zone rather less indefinite (1″).

B_2 47.5—68 cms.+. Brown with numerous reddish brown lumps of iron stone and khondalite and yellow gley marks. Indurated Occasional fine roots, no stones.

	Stones and Gravel	Coarse sand	Fine sand	Silt	Clay	H_2O	Undet.	pH
A_1	0.5	29.3	45.0	5.3	17.6	2.0	0.6	6.6
B_1	1.1	19.3	46.0	7.0	22.3	3.0	2.4	6.4

The soil profile at Vellankulam exhibited some similarities, not only in colour and physical characters, but also in the presence of a pan-like zone or of a pan-like material. Here, however, the parent rock is Miocene limestone and the soil must therefore belong to the terra rossa group.

A_1 0—37 cms. Reddish yellow to a brown sandy loam, compact, laminated, no stones or animals.

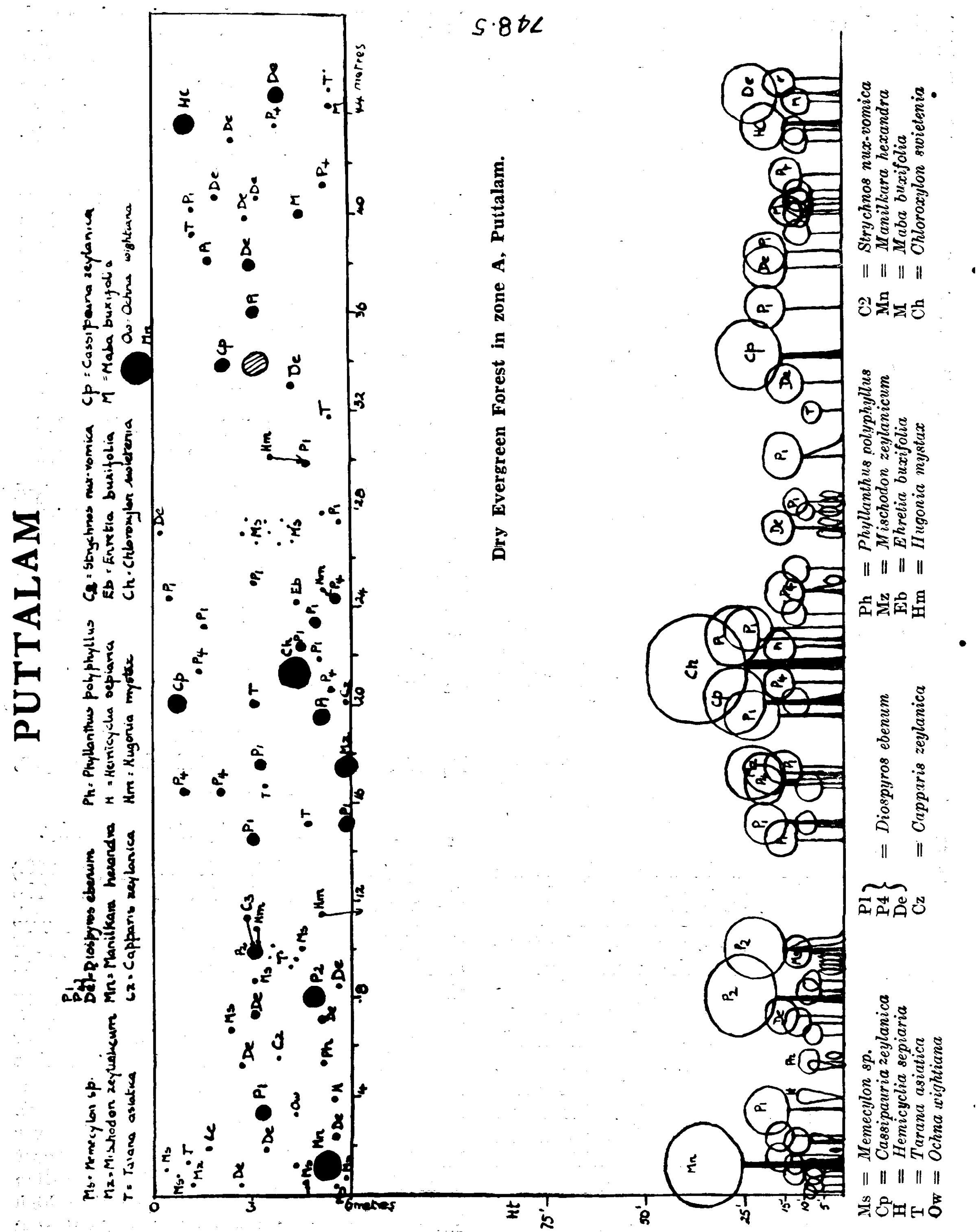
B_1 37 cms. down Indurated chocolate pan, very hard.

2. *Manilkara—Hemicyclia community.*

(*Fig. II, plate* 19 *and page* 300.) *Represented by the forest at Komari.* The two dominants are about equally represented, though Hemicyclia may not reach the height of Manilkara. In other places on the island the former may become almost dominant. Apart from the presence of these two dark-leaved species there are other trees with lighter foliage, *e.g.* Eugenia, Pterospermum, so that from the air the forest does not possess a uniform dark tone (compare with Hambantota). In this place there is an extensive ground cover but this may not be true for all areas. Apart from the difference in general composition this community seems to have a fairly high density in the shrub layer, which is dominated by *Glycosmis pentaphylla* Corr.

*I am indebted for this information to Mr. C. H. Holmes of the Forest Dept. of Ceylon.

†For classification *cf* Jacks, G. V. *Imp. Bur. Soil. Sci. Tech. Comm.* 29, 1934.



Dry Evergreen Forest in zone A, Puttalam.

The soil profile in this forest also shows the existence of a horizon containing numerous pan concretions.

Soil Flat or slight slope, micro undulations, drainage good.

A_1 0—4 cms. Brown, loose, friable, sandy loam. No stones, humus+, a few small roots, no animals. H_2O+. Transition to next layer distinct.

A_2 4—42.5 cms. Yellow-brown clay loam, compact, with more clay and silt. Stones absent, humus +. large and small roots. Water+. Transition to next zone distinct. No animals.

B_1 42.5–87.5 cms. Browny red, indurated with numerous pan concretions. Few small roots, occasional large ones, water+. Transition to next zone distinct, humus+.

B_2 87.5-126 cms.+Browny red, indurated, large pan stones almost conglomerate), rock crystals, H_2O. Occasional large roots and small rare.

	pH	Carbon	Org. matter.
A_1	6.0	2.12	3.66
A_2	5.4	1.16	2.01

Note the increasing acidity in spite of decreasing humus.

Compared with the soil at Hambantota the ground is more acid and the A_1 layer contains a much higher proportion of clay (34.8%) so that the soil is a heavy loam as compared with a sandy loam. This difference in soil, as well as in rainfall, may contribute to the difference in size of the trees, as compared with the preceding community, and in the forest composition. The soil map places this area in the pleistocene plateau deposits which are largely non-lateritic in type.

3. *Manilkara-Chloroxylon-Albizzia community (vide Fig. I, plate* 20 *and page* 306).

The principal feature of this community is the presence of the large, semi-deciduous, light-toned species in the top canopy thus giving it a distinctive appearance from the air. There are a large number of species in the shrub layer but there is little or no ground flora. Examples of what can be regarded as this type of community were encountered at Puttalam, Vellankulam, (on the red loam cap above the pure Manilkara), Nachchikuddi and Pooneryn. As far as density is concerned the two samples at Puttalam (*page* 306) and Nachchikuddi (page 304) are very similar, whilst there is also a similarity in the heights of the various storeys. The top canopy is lower than at Komari but higher than at Hambantota and Vellankulam. At Puttalam this might be accounted for by the greater rainfall, but this explanation could scarcely be true at Nachchikuddi, nor does an examination of the soil provide us with any alternative hypothesis.

At Nachchikuddi there is a sharp demarcation between the old forest and an area of secondary growth (s), where the average height of the canopy is 30 ft. : in this area (s) *Manilkara hexandra*, *Maba buxifolia* and *Hemicyclia sepiaria* are the dominants and the undergrowth is very dense. One feature, as seen from the air, is the effect of the dominant wind in producing a pseudo-row arrangement in the forest.

The soil at Puttalam is uniform to a considerable depth, but at Nachchikuddi the A horizon can be divided into three zones.

Puttalam soil A_1 0—100 cms. Light browny-yellow heavy loam, compact, indurated: no animals or stones, occasional large roots and frequent small roots (white sand group).

Nachchikuddi soil (white sand group)

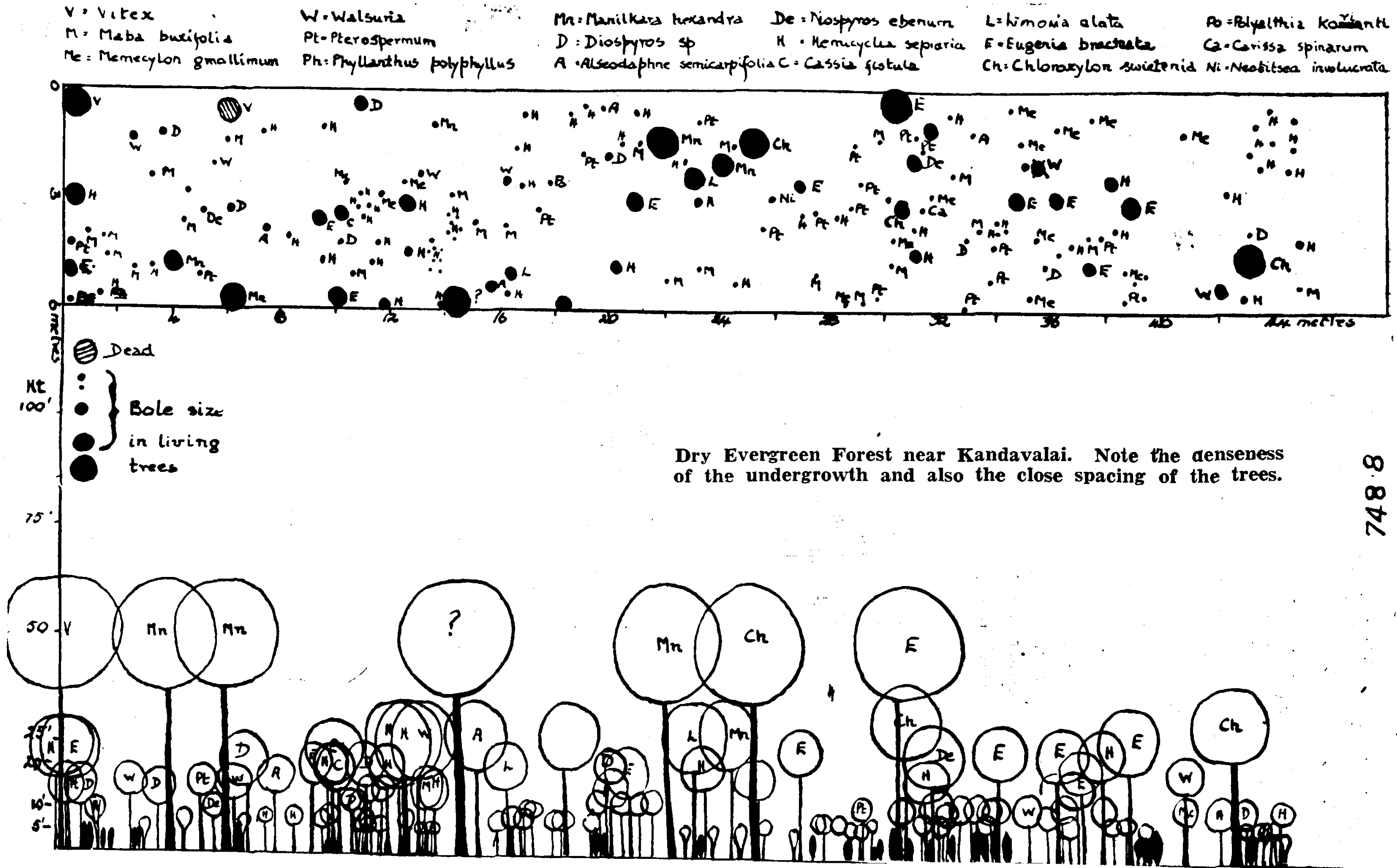
A_1 0—6 cms. Grey-black sand, light, loose, no animals or stones, numerous small roots.

A_2 6—30 cms. Light yellow sand, uniform, loose to compact, no animals or stones, numerous large and small roots.

A_3 30—60+cms. Light yellow with reddish mottlings, compact, sandy, no stones or animals; occasional large and small roots.

748.8

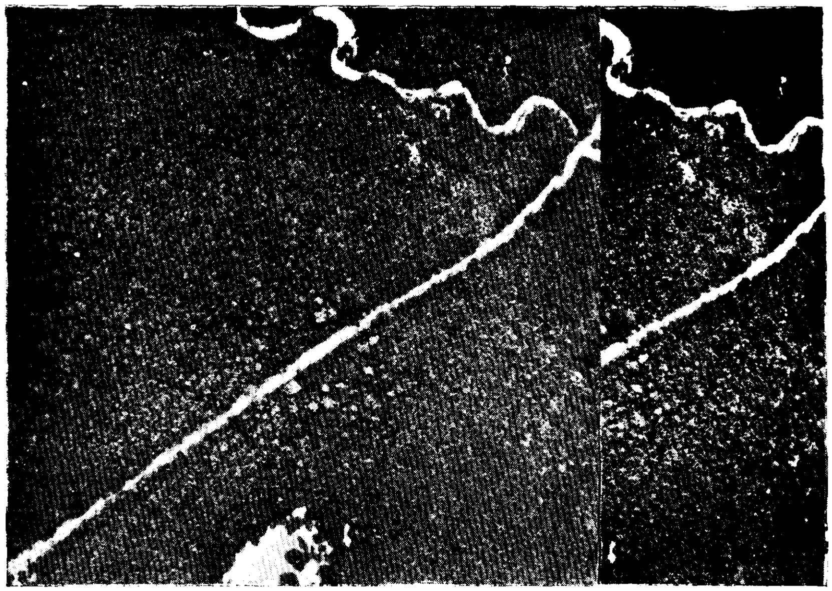
KANDAVALAI



Dry Evergreen Forest near Kandavalai. Note the denseness of the undergrowth and also the close spacing of the trees.

Vi = *Vitex*
Po = *Polyalthia korinti*
E = *Eugenia bracteata*
C = *Cassia fistula*
W = *Walsuria*
M = *Maba buxifolia*
Ca = *Carissa spnarum*
Ch = *Chloroxylon swietenia*
Mn = *Manilkara hexandra*
Pt = *Pterospermum*
Me = *Memecylon gracillimum*
Ni = *Neolitsea involucrata*
De = *Diospyros ebenum*
D = *Diospyroe sp.*
Ph = *Phyllanthus polyphyltus*
L = *Limonia alata*
H = *Hemicyclia sepiaria*
A = *Alseodaphne semicarpifolia*

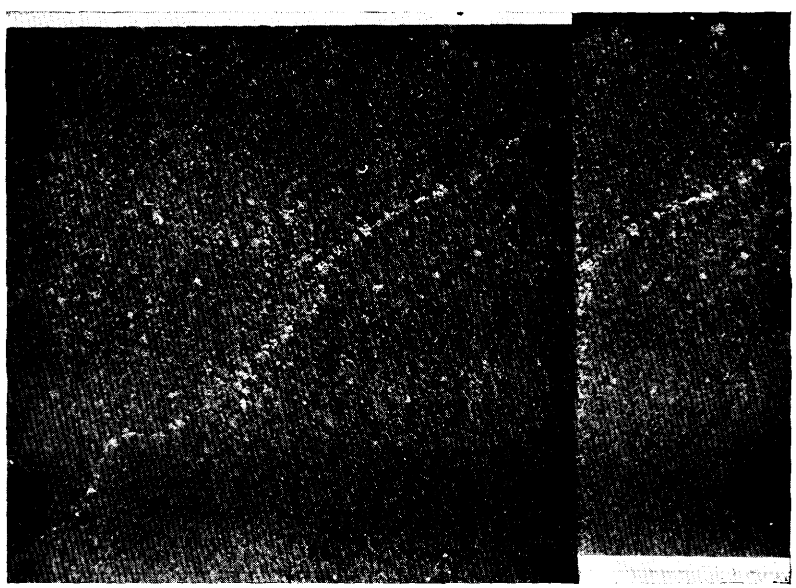
Fig. I



Kandavalai

Tropical dry evergreen forest (Mixed community). There is perhaps a rather greater range of light tones in the tallest trees than at Komari, but the two types of forest appear very alike. The low even-toned area is secondary growth (Scale 1/7200, green filter, Aug. 1945).

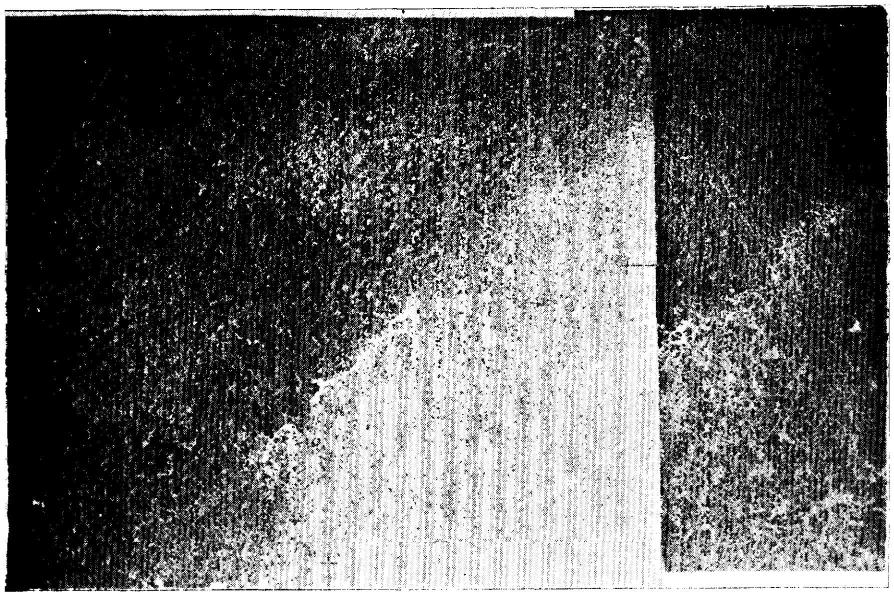
Fig. II



Oddisuddan

Tropical dry evergreen forest (mixed community). In general appearance this does not differ noticeably from the forest at Komari. The river bed lined by trees of **Terminalia arjuna** stands out very distinctly (Scale 1/9000, green filter, May 1945).

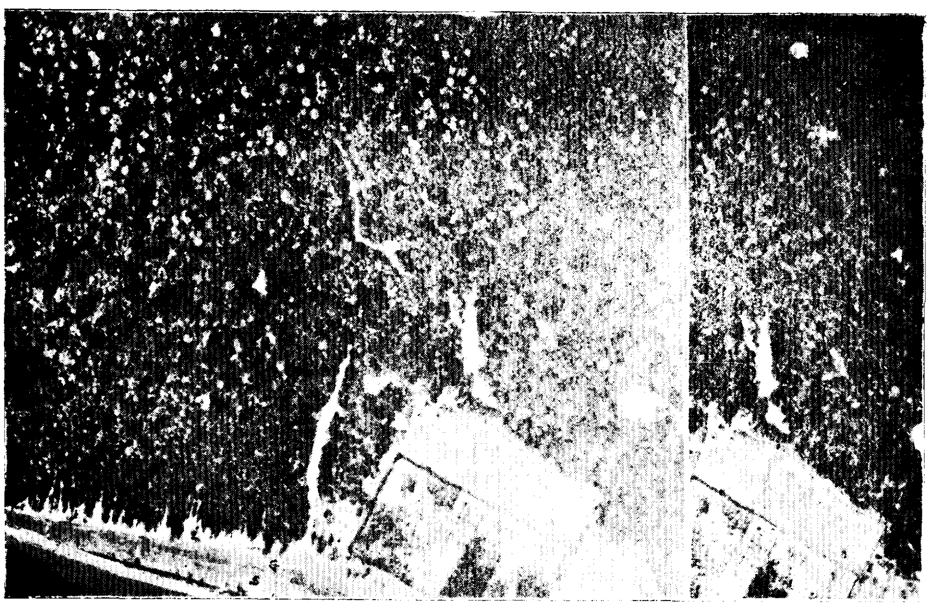
Fig. I



Vellankulam

Tropical dry evergreen forest, and thorn scrub on 'regur' soil. At the transition zone the change from the dark soil to the reddish forest soil is clearly evident. The forest is very similar in appearance to that at Puttalam (Scale 1/9000, green filter, May, 1945).

Fig. II



Nachchikuddi

Tropical dry evergreen forest (P) and near top right the same with the dominants removed or else representing secondary growth with Manilkara, Maba and Hemicyclia. In this secondary area and also at the sea front note the effect of the dominant wind upon the vegetation. The canopy of the second storey is different (lighter in tone) to that at Puttalam. The Salicornia (S) and grass zone (G) are clearly distinct (Scale 1/7200, green filter, August, 1945).

	Coarse sand	Fine sand	Silt	Clay	H_2O	Undet	pH	Carbon	Humus	Texture index
Hambantota A_1 ..	29.3	45.0	5.5	17.6	2.0	0.6	6.6	..	..	16.8
Puttalam A_1 ..	38.4	22.8	0.2	36.5	1.0	2.1	5.4	..	..	33.0
Nachchikuddi A_1 ..	61.7	27.9	0.3	5.7	2.1	2.3	6.3	2.51	4.33	5.4
Nachchikuddi A_2 ..	56.0	28.3	1.0	10.1	1.9	2.6	6.4	0.34	0.58	9.4

4. *Mixed Community.* (*Figs. I and II, plate* 21).

Although Manilkara is common in the top canopy there are a number of other species associated with it, some of them not encountered in abundance in the types so far mentioned. The density of the plants in the lower storeys is also greater (*Cf. Table* 2 *on page* 303). From a casual inspection it seems as if this type has a wide distribution in N. E. and N. Central Ceylon, though quantitative data were only secured at Kandavalai. In this place there is the old (virgin) forest and also an area between the stream and the road of what appears to be even-aged secondary growth, 35—40 ft. high with Manilkara and Hemicyclia as co-dominants in the top canopy. In this and the other types of dry forest rivers stand out clearly from the air because the trees of *Terminalia arjuna*, which line their banks, have a foliage with a different tone. (*Fig. II, plate* 21). This feature is more obvious on the green filter photographs obtained in March than on the yellow filter photographs obtained in August. It is not possible therefore to say whether it is due to the type of filter or to the season when the photographs were obtained. From the point of view of future aerial photography in the service of ecology this is a feature that requires to be investigated.

The soils at Kandavalai and Oddisuddan are very similar and appear to be widespread wherever this type of forest occurs. They belong to the dry zone lateritic red and yellow earths and seem most closely allied to the zonal gravelly soils described by Rosayro (1943). The presence of a gravel pit at Oddisuddan provided an opportunity of examining a good profile.

A_1 0—80 cms. Yellow brown compact loam, no stones, large and small roots abundant.

B_1 80—110 cms. Reddish gravel and small black pan nodules, compact, indurated, large and small roots frequent.

B_2 110—135 cms. Reddish stony gravel, loose, indurated, roots not abundant.

C_1 135—198 cms. Whitish decomposing khondalite ?

C_2 198—270 cms. Pinkish khondalite, reddish clay and iron-stone.

C_3 270 cms. + Parent khondalite.

A comparison of the differences exhibited by the four communities as seen from an aeroplane leads to the following conclusions.

From the photographs it is evident that the Manilkara community possesses an even dark tone, due to the dark foliage and compact crowns of the dominant species. The emergent trees of Manilkara stand out very clearly (*Fig. I, plate* 19), even from the dominant layer where the same species is equally abundant.

The Manilkara - Chloroxylon - Albizzia community only differs photographically from the Manilkara community in the presence of large, light-toned trees in the emergent layer. This is seen characteristically at Puttalam and Vellankulam (*Fig. I, plate* 19 and *Fig. I, plate* 20), but at Nachchikuddi (*Fig. II, plate* 20) the appearance of the dominant tree layer (flecked rather than even in tone) is so different that one may be concerned with a separate community. The Manilkara-Hemicyclia community differs from the two preceding communities in showing much more variation in tone, and also there are light-toned, small-crowned trees (Hemicyclia?) in the dominant tree layer. At the same time the trees of the emergent layer are more uneven in height, but throughout the large, dark-toned, compact crowned trees of Manilkara remain

distinct. It is very doubtful whether from the air the mixed community is distinguishable from the Manilkara-Hemicyclia association, though a comparison of photographs of plate 21 and Fig. II of plate 19 suggests that there may be a greater proportion of light-toned trees in the emergent and dominant layers of the mixed community.

Walking through all these forests of the Dry Evergreen type, one was conscious of the fact that they do differ from one another: it is believed that the sample strips do give some indication of these differences. These are only small areas, however, and larger tracts require to be studied. When this is carried out it is believed that this differentiation will be confirmed, though the ultimate composition of the communities may vary from that outlined above.

Tropical Fresh-Water Marsh (Fig. I, plate 22).

The sole example seen was the dried up tank in the Puttalam area. This was photographed both in May and September. The first photograph (right hand), using a green filter, shows the ordinary grass along the side (paler tone), then a rush vegetation which appears in the form of two rings (darker tone), whilst in the centre the vegetation changes and a new community is evident. The trees in the tank stand out clearly in comparison with those of the surrounding forest by virtue of their lighter tone. These all belong to a single species, *Syzygium cumini* (L) Skeels, which is characteristic of such areas. In the later photograph (left hand), where a yellow filter was used, the distinction between the different rush and grass zones is practically eliminated and the trees of Syzygium do not stand out so clearly. In this case it would seem that the best ecological results are obtained with a green filter. This, however, is not quite the whole story. By August this area was very much drier than in May, and the rushes were not so fresh, and in fact had dried up to practically the same brownish shade as the grass. In the dry season it is therefore very difficult to distinguish from the air between rush and grass zones (*cf.* also Mundel Lake). On the other hand there is no reason to believe that the foliage of the Syzygium had changed materially so that there is still some evidence in favour of the green filter.

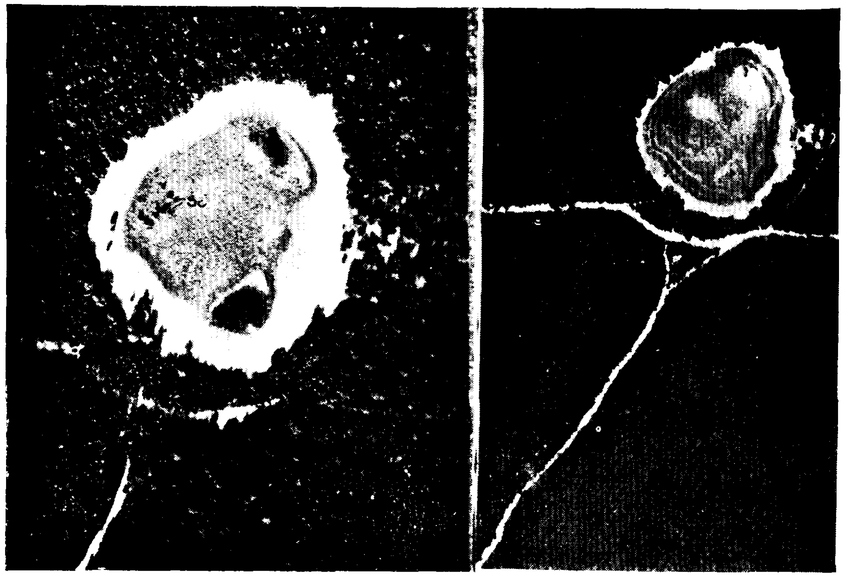
Southern Thorn Forest (Fig. II, plate 16 and Fig. I, plate 20).

This was encountered in two forms, one at Hambantota and the other at Vellankulam. It might be argued that the scrub at the former place should more properly be regarded as a community of the Tropical Dry Evergreen Forest, but apart from the presence of Hemicyclia and young Manilkara the composition is very different: *e.g.* there is much ***Euphorbia antiquorum*** L present. For the present therefore it is suggested that this should be termed the Hemicyclia-Euphorbia Semi-desert scrub community. It is found at Hambantota at slightly higher elevations than the Manilkara community of the Tropical Dry Evergreen Forest and the soil conditions must be more arid.

At Vellankulam (*Fig. II, plate* 20) the thorn forest dominated by *Acacia eburnea* Willd. is confined to the black cotton soil of the lower area. Several large areas of this black cotton soil were encountered in the region visited by Wayland (1915), and they considerably extend the total area of this type of soil as hitherto known (Joachim 1937). There is reason to believe that this extremely characteristic soil is primarily responsible for the type of vegetation found here, and that Dry Evergreen Forest will not grow on the black soil, which becomes very waterlogged during the rainy season, although these areas are not in fact stream beds. In the past, when this part of the island was more densely populated than it is now, it is also possible that these areas were put under cultivation, the forest being left untouched. Sufficient time has, however, elapsed for forest to be re-established, and the fact that it has not appeared suggests that soil conditions (*e.g.* soil water) are inhibiting. The transition between the two types of vegetation is equally striking from the air and from the ground (*Fig. I, plate* 20).

The soil differs very markedly from that of the neighbouring forest tracts. Down to a depth of 37 cms. it is grey, columnar, compact and clayey. There are numerous large and small stones and there is a high proportion of carbonate present. There is no evidence of burrowing animals (from the sample pit), and on weathering a light grey silty surface sand is produced. Wayland (1915) considers that the following three conditions are responsible

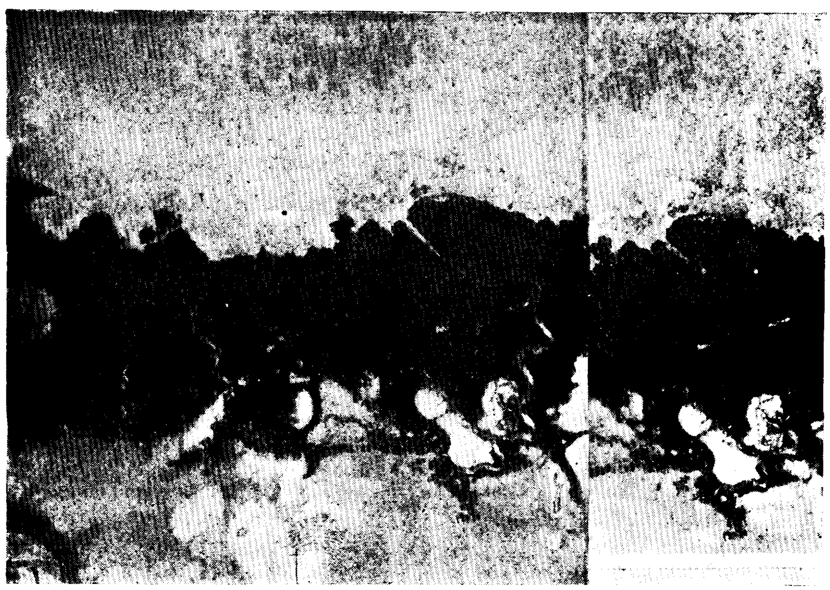
Fig. I



Puttalam

Fresh water marsh or tank. The photo on the right (Scale 1/9000, green filter) was taken in May and the one on the left (Scale 1/7200, yellow filter) in Sept. In spite of filter differences the changes in the appearance of the tank due to season are more than obvious. Sc= **Syzygium cumini.**

Fig. II



Viddataltivu

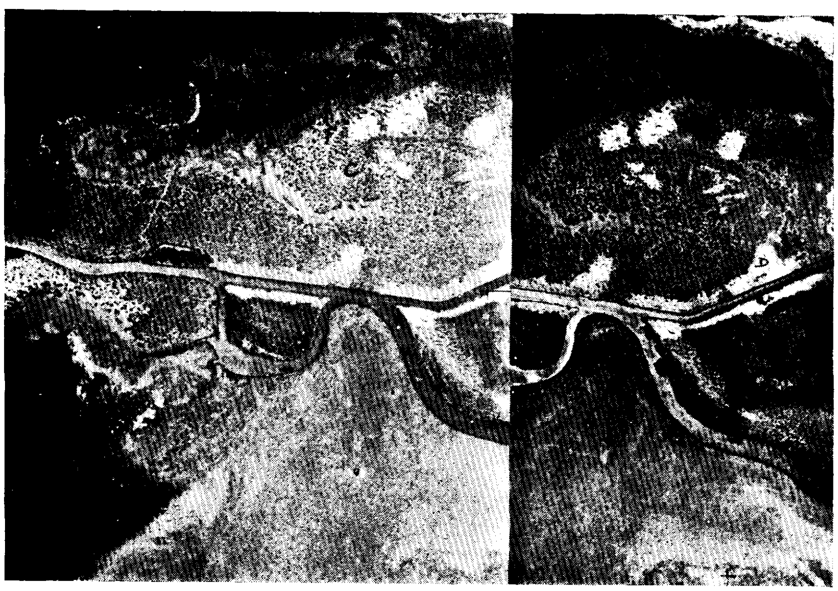
Mangrove swamp. Large Avicennia on the sea face is lighter in tone than the smaller trees behind. Along the banks of the creeks the very dark patches of Rhizophora are clearly visible. On the landward side note the colonisation proceeding along the edges of creeks and in depressions of the lagoon (Scale 1/9000, green filter, May 1945).

Fig. I

Nachchikuddi

Tropical submarine phanerogam formation. Note the sharpness of the under-water outlines of the beds. The different tones may be due to different species. (Scale 1/7200, green filter, Aug., 1945).

Fig. II



Mundel Lake

Tropical salt flat communities. Note how the various zones stand out. A=rush zone; B=**Zoysia pungens** with occasional mangrove bushes; C=open ground with Suaeda bushes and some ground cover; D=the same but without ground cover; E=bare mud; F=Halophida; G=mangrove. Compare this with the next photo taken 6 months later (Scale 1/9000, green filter, May, 1945).

for the origin of these thorn scrub tracts, which he maintains are slowly extending their area.

(1) Exposure of the sedimentary beds, possibly at a time when the rainfall was greater.

(2) Inability of the sediments to take up moisture to any considerable extent, thus leading during the hotter seasons to the entire depletion of their free water content.

(3) The air spaces between the particles of the perfectly dry soil resist the downward percolation of the rains when they fall.

The result is a heavy clay soil water-logged in the wet season and setting very hard in the dry season. The soil can therefore be regarded as physiologically dry and hence it bears an edaphically determined xerophytic vegetation. There is no doubt that these areas are among the most interesting to be found in Ceylon, and in many respects it is perhaps fortunate that they are so difficult of access.

Beach (Strand) Forest Formation
(Fig. II, plate 19).

Beach forest in South East Asia can be regarded as occurring in a number of forms: (*a*) Casuarina consociation, (*b*) broadleaved beach forest association (*c*) beach scrub association. The last named is to be found at Komari where it forms a narrow fringe to the Dry Evergreen Forest lying behind, although isolated patches of the scrub occur on the front ridge of dunes. It proved impossible to detect this type of vegetation from the air because it merges imperceptibly into the forest. The species, which form this dense beach scrub zone at Komari, are *Memecylon umbellatum* Burm., *Mallotus rhamnifolius* Muell., *Toddalia asiatica* Lamx., Capparis sp. *Bauhinia racemosa* Lam. and *Abrus precatorius* L.

Eastern Tropical Sand Dune Formation
(Fig. II, plate 19).

This is of widespread occurrence and can probably be divided into a number of associations. The only area examined in detail was at Komari* where it occupies the fore dune, whilst isolated plants occur in the hollow between this and the hind dune. It can perhaps best be described as a Spinifex-Ipomoea-Scaevola association, though in many areas the Spinifex forms such a large proportion of the vegetation that it is virtually a Spinifex consociation (*e.g.* Puttalam, Vankalai).

This association is usually visible from the air as may be seen from the photograph.

Eastern Mangrove Formation
(Fig. II, plate 22).

At least two communities of this formation were recognised in Ceylon though others doubtless exist, but all are somewhat attenuated as compared with those of India, the Malay Peninsula and Indonesia. Forming a frontal zone in sheltered places and also along rivers there is commonly a belt of a Rhizophora mucronata consociation. Behind this one normally finds an Avicennia intermedia consociation though other species of Avicennia may be admixed. It is not unlikely that in places *A. officinalis* is the dominant.

Probably one of the most extensive mangrove swamps in Ceylon is that north of Mannar at Viddataltivu (*Fig. II, plate* 22). This was studied with some care and it appears to consist for the most part of a pure crop of *Avicennia intermedia* Griff. The trees are tallest at the sea face, but here *Ceriops candolleana* Arn. and *Rhizophora mucronata* L. are admixed. This mixture continues down the creek banks and it is clearly obvious on the air photographs from the darker colour of the *Rhizophora*. Towards the centre of the swamp the trees become smaller (about 12 ft.), and then on the landward side they increase in height again (15-20 ft.), except at the very edge where colonisation of the lagoon is slowly taking place. Colonisation is principally occurring along the edges of creeks and in slight depressions, where the seedlings can apparently survive, but although some plants do become established on slightly higher ground many of them subsequently die. The different degrees of submergence in these two places would be of very considerable interest, because they would indicate to some extent the conditions essential for colonisation.

The difference in foliage colour enables a clear distinction to be drawn between the species, and mangrove swamps are undoubtedly areas where air photography is not only of value

*Examples of this community were also seen at a number of other places.

from the mapping aspect (*cf.* Scott, Robbins *et al.* 1925), but also could be of extreme usefulness in their ecological interpretation. In parts of the East Indies the distinction between species is far more pronounced than it is in Ceylon and it is in such places that air photography is of great value.

A series of soil samples were taken in the swamp at Viddataltivu and they show a clear graduation from sea face to lagoon :

	Coarse sand	Fine sand	Silt	Clay	H_2O	Undet.	pH	Texture Index No.
Sea face	16.4	20.0	6.0	39.4	7.0	11.0	6.3	36.1
Middle	32.3	23.0	3.4	30.4	4.7	5.9	5.8	28.0
Lagoon side ..	12.7	36.6	2.6	35.1	6.2	6.8	6.9	31.9

In all the samples there was a very high proportion of $CaCo_3$ due to the remains of molluscan shells.

Tropical Submarine Phanerogam Formation (*Fig. I, plate* 23).

The photographs at Nachchikuddi showed the presence of dense vegetation underneath the water. In colder latitudes this would generally be seaweeds, but in lagoons of this type and in many places in the tropics so-called submarine grasses occur in considerable quantity. The ecology of these 'grasses' has not been studied in any detail and it is a problem that requires to be undertaken. A brief survey in Puttalam lagoon showed that *Halophila ovata* Gand. is largely confined to the shallow waters near the shore, *Cymodocea issetifolia* Achers. is found in deeper water, whilst *Enhalus Koenigii* Rich. occurs in deep or shallow water but seems to occupy places where the soil is rather more sandy.

The photographs off Nachchikuddi also suggest, from differences in tone, that the distribution of the species may perhaps be discernible from the air if this should prove to be correct then we have here a valuable tool in the hands of ecology.

It might be argued that the dark patches were either rocks or seaweed beds, but as seaweed normally only occurs where there are rocks or boulders and the marine phanerogams where there is sand, this confusion should not arise because bottom conditions can be ascertained independently from Admiralty charts.

Tropical Salt Flat Formation
(*Fig. II, plate* 20 ; *Fig. II, plate* 23 ; *and Fig. I, plate* 24).

This is represented in Ceylon by several associations. There is a Salicornia association composed apparently of several different species of Salicornia. So far only one species of this genus has been recorded from Ceylon but it is clear that a number of species, and probably also hybrids, exist, and these will be described in a separate paper. The Salicornia association may cover a considerable area, *e.g.* on the Kalpitiya peninsula, or it may be rather more restricted, *e.g.* south of Mannar. A fairly wide belt occurs in front of the grass sward at Nachchikuddi (page 304) and it appears from the air as rather lighter in tone than the grass.

Another community is the *Suaeda* association in which *S. monoica* Forsk., *S. nudiflora* Moq. and *S. maritima* Dum. occur in varying proportions. There is also a *Scirpus littoralis* consociation in which other species, *e.g. Cyperus naspan* L. participate, and a Zoysia pungens consociation. Mundel Lake proved very interesting because a number of these maritime communities were present in distinct zones. Subsequent investigation will probably show that they are correlated with the amount of salt in the soil, or more particularly with the amount of free chloride ions. The photograph (*Fig. II, plate* 23) taken in May shows the following zones :

A. Rush zone with *Cyperus haspan* L. and *Scirpus littoralis* Schrad.

B. Zoysia pungens consociation with occasional low trees of *Avicennia intermedia* Griff. and *Heritiera littoralis* Dryand.

C. Open ground with bushes of *Suaeda monoica* Forsk., some Zoysia and *Eleocharis setacea* (Retz.) R. Br.

D. Open ground with bushes of *S. monoica* Forsk. but no other ground cover, though occasional plants of Zoysia and *Arthrocnemon indicum* Moq. are present.

Fig. I

Mundel Lake

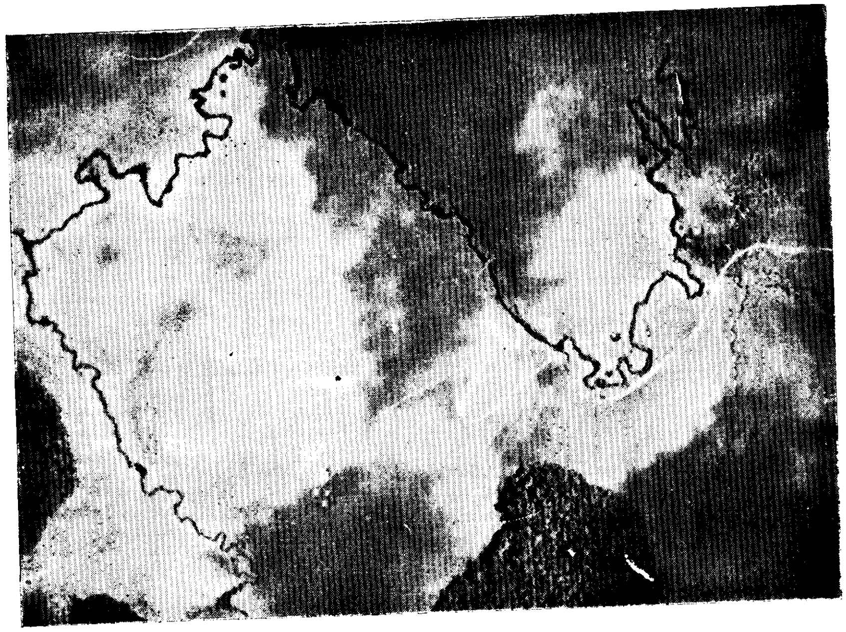
Tropical salt flat communities. The same area as the previous photo after it had been dry for a long time. Zones A and B are now practically indistinguishable (Scale 1/9000, green filter, Aug., 1945).

Fig. II

Eandarawela

Tropical grassland formation. Cymbopogon confertiflorus-Imperata arundinacea association of the dry patanas (Scale 1/9200, green filter, May 1945).

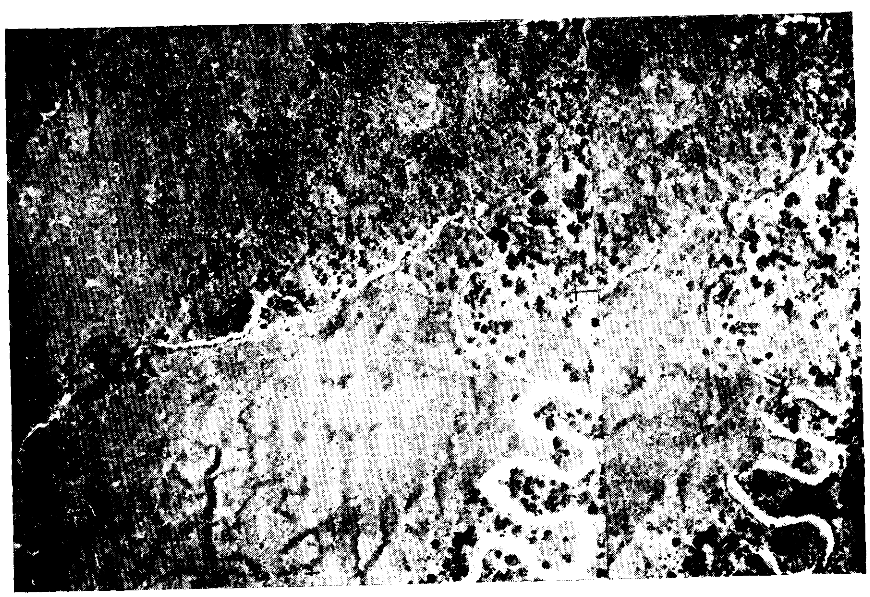
Fig. I



Ambawela

Tropical grassland formation. Chrysopogon zeylanicus-Arundinella villosa association of the wet patanas. Along the streams there is a difference in the vegetation where **Carex walkeri** is dominant (Sacle 1/7200, yellow filter, Sept., 1945).

Fig. II



Mahaweli Ganga

Tropical grassland formation (Damanaland) and Savannah. At least two different grass communities are present, a darker vegetation occurring in the damper depressions (Scale 1/9000, green filter, May, 1945).

E. Bare mud with a felt of blue-green algae in places.

F. Zone of *Halophila ovata* Gand.

G. Mangrove swamp dominated by *Avicennia intermedia* Griff.

The *Zoysia pungens* consociation was seen again as a cropped sward at Nachchikuddi (*Fig. II, plate* 20) and also at Pooneryn where all the flower heads were galled. The Suaeda association occurs again around Puttalam, Mannar and Mullativu and is no doubt frequent elsewhere.

The interesting feature about Mundel was that later in the year (August), when the area had not been flooded for a long time, the rushes had become so dried up, that as a zone they could not be distinguished in the air from the Zoysia consociation although the difference was obvious on the ground (*Fig. I, plate* 24). Here again season is an important item in successful ecological photography.

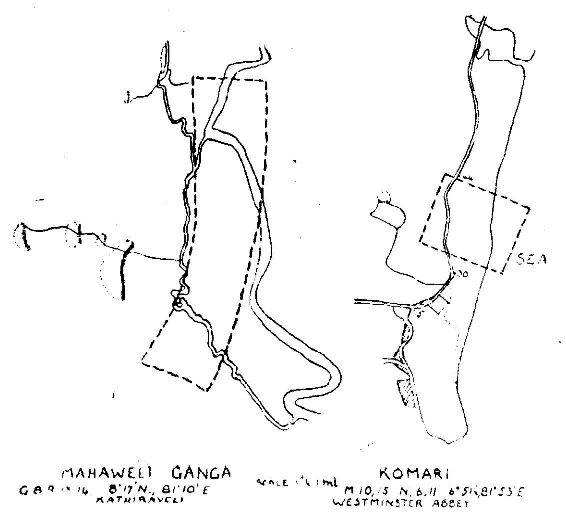
Tropical Grassland Formation (*Fig. II, plate* 24 ; *plate* 25 ; *and the text fig. below*).

This is represented in Ceylon by at least three communities (four according to Holmes, 1946) :—

(*a*) *Chrysopogon zeylanicus-Arundinella villosa* association of the wet patanas.

(*b*) *Cymbopogon confertiflorus-Imperata arundinacea* association of the dry patanas.

(*c*) *Talawa* and *damanalands** of the wet and dry lowland plains.



Areas covered by air photographs at Komari and on the Mahaweli Ganga. Grid references to the ordnance survey sheets.

The first of these communities occurs over a wide area adjacent to the montane forest, and a portion is seen in fig. II, plate 24. The cover is fairly uniform except near the beds of streams, where a community dominated by *Carex walkeri* Arn. is to be found. This shows on the air photographs as slightly coarser in tone. The surface layers of the wet *patana* soil are black, gritty, loose and friable. In many respects it has the appearance of peat, but I believe the black colour is due very largely to the repeated burnings ; the perpetually moist climate prevents the burnt organic matter from decomposing and then it becomes partially washed down into the soil without much change. There would seem little doubt that burning and grazing (Cf. Senaratne, 1943) are responsible for the maintenance of this grassland subclimax, as they are also in the dry *patanas* and *talawas*. In certain places one can see how the fire penetrates a little way into the forest and encroaches upon it. Generally the fires stop at the forest edge because the conditions there are too moist. In places where fires have not occurred for some considerable time there is evidence of forest spreading out into the *patana*. A very large number of species occur in the *patana*, but as lists are available (Pearson, 1899 ; Holmes, 1946) it is not proposed to provide one here.

Examples of the other two types of grassland are shown in Fig. II, plate 24 and Fig. II, plate 25 but no ground check of these areas was made.

Conclusion

In this paper an attempt has been made to give a brief account of some of the different vegetation types of Ceylon as seen not only from the air but also from the ground. Points of interest that arise from the air photographs have been indicated, especially where they can be of definite ecological value. It is hoped that these may serve as a basis for future work. This study can only be regarded as preliminary in nature because the time at our disposal did not permit of more detailed work. Some of our conclusions may have to be modified, but it is hoped that the general interpretation will remain valid.

This work could not have been carried out without the co-operation of a number of persons and it is a pleasure to thank them for their contributions. These persons are

C. O. Flemmich, Esq., T. Wyatt-Smith, Esq., of the Malay Forest Service and Dr. J. L. Harley of the Botany School, Oxford, who assisted in the ground surveys; the Forest Dept. of Ceylon for help, and in particular C. H. Holmes, Esq., and Dr. C. de Rosayro; Mr. J. S. Seneratne of the Herbarium and the Collector at the Royal Botanic Gardens, Teradeniya, for help in identifying our mass of material and Dr. Joachim and staff for help with the soil material. I am particularly grateful to Dr. Joachim for advice and criticism in those portions dealing with the soils. Mr. L. H. Millener of Auckland also read through the script and made useful suggestions.

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THE CONCEPTION AND CLASSIFICATION OF THINNINGS.*

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SUMMARY.—In making a thinning in a crop, foresters seldom agree. They rely on instinct (or experience or the so-called knowledge of the silvicultural requirements of the crop) as little more is understood about thinning beyond the fact that it consists in the removal of some of the worst trees in the crop. The theory of dominance of trees and the commoner mode of diagrammatic representation has added confusion to the paucity of knowledge. In this paper, the present position has been examined, the nature of thinnings and their regimes, as related to the laws of growth studied, relationship between crop dimension and differentiations stated, the basis of a relevant tree classification evolved, thinning order list revised, and natural grades of thinnings enunciated. The basic foundations of all the rational and empirical methods of thinnings have been analysed and correlated and a few other important questions relating to thinnings explained. The genesis of this very briefly written paper is the freedom of the crown, as opposed to the prevalent universal ideas about dominance in tree crops.

Introductory

Thinnings, the most important and commonest of all silvicultural operations, have puzzled and even baffled thoughtful foresters ever since the first classification was evolved. Even when the D or E grades of thinnings were not much talked about, the favourite C was a perpetual problem. The limits of various grades contract and expand with the whims of individuals and it is rare that two foresters can agree on a marking. The research worker has sought refuge in mathematical checks but is still overwhelmed by the relationship of thinning cycle to the grade. Thinning continues to remain elusive.

The causes

The present state of affairs is not at all surprising if it is realised that every forester is expected somehow or other to possess instinctive knowledge of thinnings. The text-books and teachers talk of competition, suppression and differentiation of trees in a crop and of the time, periodicity, and intensity of thinnings, but never a word is said about the nature of thinnings. This ignorance of its fundamental nature is the primary cause of the lack of grasp of the subject and consequent difficulties.

But the most important and the direct cause of the difficulties is the very basis of the canopy and tree classification on which the various thinning grades are, in turn, based. A classification of the trees into grades, suitable for retention or removal is of course necessary, though this need not necessarily form the basis of thinnings. It is indeed amazing to think how dominance ever came to form the basis of tree classification, designed for thinning purposes. A thinning is made to provide space, horizontal space to be more precise (as in a crop the former is directly proportionate to the latter), and if tree height, instead of crown spread, is adopted as a guide, then trouble is bound to follow. The adoption of dominance in place of spread as the basis of tree classification is not the only queer thing about thinning as at present understood, but as will be seen from later discussion the whole conception is topsy turvy. What should really form the basis of all thinnings are treated as mathematical checks, while tree classification which should primarily be a guide only is treated as the sacred inviolable basis, the grade is confused with thinning regime and the regime is not recognised at all.

Another cause that has done incalculable harm to a proper understanding of thinnings is their diagrammatic representation in elevation. The authors, in view of the adoption of dominance as the basis of tree classification, naturally consider this as quite a normal and easy method, but it has often rendered the less imaginative foresters into believing thinning as not a multi-plane but a one-plane operation (as in diagrams), making spacing look rectilinear, individual, and rigid, rather than radial, average, and elastic.

*Paper read at the 7th All-India Silvicultural Conference (1946), Dehra Dun, on item 15—Thinning Research. The conference resolved that the technique proposed in this paper should be further examined with the collaboration of the author. Expression of views from readers will be welcome.—*Ed.*

Some facts about growth

Each tree develops a certain shape. Both development and shape vary with species (including strains), locality, age, and space; and any change in locality or space (resulting from treatment) may either affect vigour or shape but generally both. Under identical or similar conditions however the growth and shape are alike. The same principles apply to crops and to the average tree. Of all the factors affecting growth and shape, space is the only one that can easily be manipulated at will. Trees, with plenty of room, grow vigorously, lay thick tissues, develop a large crown and a short, fat, conical stem, while in dense crops the trees are more or less suppressed, develop small crowns and tall, clean, straight, cylindrical and thin boles. By the manipulation of space it is possible to produce trees of practically any shape or vigour in between the two extremes, or fairly vigorous trees with some desired qualities improved and some serious defects removed.

The forester deals with crops and is therefore concerned with the production of the average tree and not of individual trees (a most important distinction the realization of which will enable foresters to accept other than the best trees as normal components of the crop). Silvicultural management therefore aims at the development in the shortest possible time and the smallest possible space of an average tree of a definite shape that yields the maximum quantity of the best quality of the forest produce required. The shape of this average tree must therefore vary with the object of management.

Thinnings

The development of an average tree is a gradual process which must be planned. As plants grow the demand for light, water, air, salts and space increases and a ruthless competition ensues in the crop. (To facilitate discussion, it will be best to deal with a simpler case of an even aged pure coniferous crop on easy ground, managed for the production of large sized timber). Above ground this competition becomes visible when the branches of the crowns of adjoining trees begin to touch and interlace with each other. The interlacing or visible competition starts at the bottom of the crowns and goes up the tree as competition continues, killing out the lower branches in course of time. Below this interlacing the tree becomes crownless forming a tall clean bole, while above it the crown is free and active and its extent primarily determines the vigour of the tree.

It is clear therefore that the shape and vigour of trees, during the course of development of a crop are determined by the level (metaphorically for trees and actually for crowns) at which competition is kept, by controlling spacing. While the increasing demands of the growing trees for light, water, etc. are all met by providing more space, and the vigour and rate of growth of trees, improve as space becomes more plentiful, yet a limit has to be imposed on this expansion to produce the largest number of trees of suitable dimensions (shape).

A thinning therefore consists in removing such of the least promising and undesirable trees in a crop that it leaves as evenly spaced as possible just the right number that will lead to maximum production of the desired trees. It is therefore the retention rather than the removal that determines a thinning. It provides more space, no doubt, to growing trees, but its essential feature is the control over the rate and extent of such an increase. Thinning is meaningless without a reference to the stock left. Removal and retention are complementary and inseparable and so are their intensities. The one increases as the other decreases and as the latter can be expressed in terms of a definite mathematical figure, the same or a corresponding expression is the best indicator of the former. Thinning therefore is a function of numbers; the numbers determine the shape of the average tree and the maximum production of the forest produce required. Thinning is one continuous process of removal and retention of trees in a crop from the pole stage to maturity.

Thinning regime

What treatment of a crop will result in maximum production can only be found out by experiment and interpolation. Theoretically, the number of trees to be retained may be almost as large as in a virgin forest or as small as would just prevent the factors of the locality getting lowered, or any number in between the two extremes. The treatments are not limited to the number of trees retained till final felling but also vary with the course the numbers follow during successive thinnings

(best called "regime" and indicated by number of stems/age curve). With so many treatments possible it may seem impossible to carry out any comparative experiments and to fix a standard for comparison, but for all practical purposes 3 to 5 curves with similar trends and their variations with sharper and flatter bends, earlier or later in the course, are quite sufficient; and fortunately we have yield tables for most of the important species, the figures of which or of the "C" grade in multiple yield tables can safely be adopted as a standard for comparison and continue to be called the "C" regime of thinnings. In the study and development of science, it is necessary that no data or experiment should be wasted and this is the greatest reason for adopting the yield table figures for the standard proposed. As a matter of fact, in this paper every effort will be made to retain as much of the form and figure of the past experience as possible. Following this principle, it seems desirable to grade other treatments in terms of 20 per cent variations, though 10, 15 or 25 per cent are equally feasible. Thinnings resulting in the retention of 120 (130 to 110), 100 (110 to 90), 80 (90 to 70), and 60 (70 to 50) per cent of the number of trees shown in yield tables may also continue to be called the B, C, D, and E regimes of thinnings, till research establishes the adoption of curves with different trends as more suitable; such grades for purposes of research being indicated, by combination of these and other letters depending upon whether the new curve lies on the concave or convex side of the main grade curve and other peculiarities.

Relationship in a crop

Were thinnings actually to be carried out on the basis of age and number of trees, they would be impossible except in regular artificial plantations of known age, as the determination of the age of a natural crop is not an easy or a simple matter. A wonderful relationship however exists between the various components of the growth of crops, which makes it possible to substitute the more convenient of them for age, with reasonable accuracy.

It has already been seen that under identical or very similar conditions the growth of crops or of the average tree is alike. Not only are the crop or average *(tree)* diameter, height, basal area, crown spread, volume, spacing, form factors and all other quantitative measurements the same but even the qualitative characteristics such as extent of competition, suppression, differentiation, the occurrence and frequency of different classes of trees, and quality of the forest produce are also alike. If any one of these various items, say, for example, diameter, or height or volume, is known, then all the remaining items are also automatically known, giving a complete picture of the entire crop. When any one factor governing growth changes, as for example, age, then the whole picture as also all the component items of the crop change, and yet there is a regular relationship in these changes which for any of the two items can best be represented by a graph. The growth factor itself, in this case the age, can also be located if any one measurement of the crop is known.

When another growth factor, such as treatment or locality, also varies, the relationship graph changes its course and two items are needed to locate it to get a complete picture of the crop. The quality of the locality or the treatment (regime of thinning) the crop has received also become known along with the age. Next to numbers, the easiest item to determine in a crop is the average diameter and these two are therefore generally adopted to determine the regime of thinnings on any particular quality of locality.

Tree classification

Having determined the number of trees to be retained after thinning in any particular crop, the next problem is the selection of the surplus trees to be removed or the determination of principles on which this selection should be based. The latter presents little difficulty. The main object of thinnings is the production of a particular kind of average tree and any that are not likely to make one, must go, the earlier the more they interfere with the future development of the promising trees. The farther away a tree is from the average, the less likely it is to develop into one, and therefore the less desirable it is for retention. Is there any differentiation in the crop indicative of the probabilities of a tree developing into the desired average tree? Several differentiations came into view at once; as a matter of fact there is differentiation in every item or dimension of growth, but those of crown volume, height, and diameter are most conspicuous. They are all related to each

other in the average tree and also to space which determines not only probabilities, but the actual future development of trees. It must however be remembered that these relationships between crown volumes, or height, or diameter, and space are average, and what holds good in the case of the average tree does not hold good in the case of every tree; and deviations are not only inconvenient but also very common. One can easily visualize what a mess it would make if thinnings were guided by diameter differentiation, and height (the basis of dominance) differentiation would not have fared any better had the other differentiation of crown volume, which includes a good element of space, been not tagged on to it at the same time. Though this double guide complicated the resultant differentiation, it saved thinning operations from serious pitfalls. But by far the greatest stability of the system has been achieved by the adoption of suppressed and dominated trees as classes of dominance (not in terms of height or crown differentiation but in terms of another abstract quality) and the coincidence of these classes with those resulting from crown spread differentiation. Were we really looking for such a complex and yet vague guide as dominance differentiation? Is there nothing simpler than this? Of course there is and a much more direct one.

The probabilities of future development of trees depend upon space, and the spread of its crown, *the free crown* and no more, gives a direct answer to the query. Competition in a crop results in variations in crown spread, the earlier occupation of space by crowns of some trees preventing and retarding the normal development of others. The differences increase with competition and though all stages of the struggle can be seen in any crop, a convenient division of the crop can be made into the following five tree classes :—

I. Spaced.—Trees with spread of free crown about equal to that of an average tree. Includes over-spaced trees.
II. Sub-spaced.—Trees with free crown spread about half of the normal.
III. Unspaced.—Trees with negligible or much-reduced free crowns.
IV. Ousted.—Trees with no free crown or vigour.
V. Dead and dying.

Thinning order list

In selecting trees for removal, the extent of the free crown spread is not the only consideration where quality of any kind is expected in the produce. For timber production, stem development acquires equal importance if not more and on its basis three further classes may be recognised for the spaced and sub-spaced and only two (good and bad) for the unspaced trees.

(*a*) Good.
(*b*) Fair.
(*c*) Bad.

On the basis of free crown spread and stem quality the trees in the following list are arranged in the order of urgency of removal.

Dead and dying	V
Ousted	IV
Bad stemmed	IIIc, IIc, Ic
Unspaced	IIIa
Fair sub-spaced	IIb
Sub-spaced	IIa
Fair spaced	Ib
Spaced	Ia

There are two special features of this tree classification. Firstly, the factors governing classification have been reduced from the usual three, (canopy class, crown, and stem) to two which is a great advantage. The relative height of trees has little significance in thinnings, it has been the cause of confusion, and is therefore omitted.

As a matter of fact the quantitative as well as the qualitative development of trees in a crop are both functions of space and there should therefore be not even a second factor governing the classification of trees, but space provides for only normal development and not for accidents or freaks, which are of considerable value when the objects of management are the production of any particular kind of produce. Hence the second factor.

Secondly, the diseased trees have not been separately classified as they all cannot possibly fall in the same category as far as the urgency of their removal is concerned. In extremely bad cases they can be classified as dying. When crown alone is affected they may be included in ousted and where stem alone is affected the disease may well be classified as any of the other stem defects.

Thinning scales based on tree classification

It may be noticed that if trees are felled according to the order or the urgency of removal a point is bound to be reached when the trees left just equal the number required under a particular regime. The question must therefore be answered, "How far can a thinning be carried out in terms of the grades of tree classification"?

Not the old classification based on dominance (height), where a *dominant tree may even* be almost spaceless, but the new classification under which all spaced trees are dominant and vigorous. It has been seen already that under a given set of conditions the development of a crop follows a definite course, not only quantitatively but also in such matters as crown differentiation, etc. This differentiation is however so *gradual and continuous* that, except in the case of ousted and to some extent unspaced trees, it is impossible to define where one class ends and where the other starts. Once a thinning is over or underdone the future differentiation will be different and if further thinnings are based on the same standard and resulting differentiation, the development of the crop will go on changing. In other words, the tree classification being relative, there is no knowing whether the thinning done is leading to the formation of the particular average tree or not. Besides, thinning primarily consists not in removing trees with a certain form or shape, but in guiding the development of those that are left; and to do this the order of urgency of removal has often to be modified. Evenness of spacing is of importance not only because it results in even growth but it also ensures maximum utility of the factors of locality. In dealing with crops, one has to think not of the individual performance of trees but of team work and of collective development. For these reasons it is not possible to base thinnings on tree classification, but after marking a sample in the proper way the crop can be marked on the basis of classification with a fair degree of accuracy. A relationship would have to be found (by working plan officers at the time of writing up and revision of plans) between the prescribed regime of thinning and the extent down the thinning order list to which trees could be felled, commonly known as the grade of thinnings. As a matter of fact there is no other easier way of carrying out markings. One thing however must be very clearly understood that though the grade depends upon the regime of thinnings it also changes with age and there is therefore no permanent relationship between the two. Every successive thinning reduces the frequency of the classes of trees removed, narrows the range of classes included in it and increases the grade. A lighter regime of thinning may in a young crop include for removal only dead, dying ousted and bad stemmed trees (classes V, IV and (III, II and I) C) and perhaps some of the unspaced (IIIa), but past middle age, the same is likely to include only unspaced (III) and perhaps some of fair-sub-spaced (IIb). It will only lead to confusion if any attempt is made to express grades in terms of regimes (A, B, C, D, E or combination thereof) and *vice versa*. Grades can most simply and advantageously be expressed *in terms of the class* up to which the trees are removed, as detailed below:—

1. "Ousted" Class V and IV.
2. "Unspaced" light.—"Ousted" and classes (III, II and I) C and some of IIIa.
   Heavy. "Ousted" and classes (III, II and I) C and IIIa and some of IIb.
   Light.—"Unspaced" and classes IIb and some of IIa.
3. "Sub-spaced" heavy.—"Unspaced" and classes II and some of Ib.
   Light.—"Sub-spaced" and classes Ib and some of Ia.
4. "Spaced" heavy.—"Sub-spaced" and classes Ib and several of Ia.

In the higher grades of thinnings where trees receive comparatively large space, the ousted and unspaced lose practically all significance as competitors and may be retained to fill up gaps.

These grades are not very suitable for thinning older crops, as the differentiation there is not so well marked as in younger crops.

The regime and the grade

The difference between regime and grade of thinning may be cleared by giving an analogy. Thinning started like sailing over unknown seas to an expected land. The only guide to start with was rough direction, and with deviations on either side the goal was reached. Having reached the other end and prepared charts of the route, the only proper course in future trips is not to ignore the route and start on the basis of rough direction again but to take related routes, either parallel or deviating, to find out if there is not a shorter one or one leading to a better post of destination. Not that direction is of no further use but it must be determined at various stages of the journey by the charted route. The relation between regime and grade is exactly that of route and direction, one plans and the other executes. There is no question of following the grade (undetermined grade) where yield tables exist

but there is no alternative to grade where the yield tables don't exist. Regime and grade must not be confused with each other. The former relates to the whole set of thinnings from pole stage to maturity (to tending as a matter of fact) and the latter to the type of removals at each thinning operation. To further differentiate their identity the terms A, B, C, D, E have been retained to denote regimes, while grades have been designated by the exclusive type of tree class included in it, which is more expressive and logical.

Crown canopy and space measurement

The harm done by diagrammatic representations of thinnings in elevation only has already been alluded to. It has in practice resulted in leaving an impression that trees left after a thinning should have space all round them and that this space must close up before being opened again in succeeding thinnings. Actually the form of opening varies with the age of the crop. In early youth it is possible to provide extra space all round the tree retained, but later on it gets restricted to a sector which keeps on changing and becomes smaller and smaller with every succeeding thinning. Nor do all the gaps, made by thinnings, necessarily close up before the next thinning; they might take another cycle or so to close up, but in the meanwhile other gaps are created, so that the canopy is really never fully complete. The only way to represent changes in the canopy diagrammatically is to show them in plan, which will make it easier to understand that spacing does not refer to the distance from any one tree to another but to the average of radial distance to all immediately surrounding trees.

Buoyancy and elasticity in thinnings

The average and radial nature of spacing, its sectional extension and its definiteness give thinning operations their characteristic variety, smoothness, elasticity, and buoyancy. The removal of a tree does not double the distances of the surrounding trees but leads to extension of space with just a mild jerk; there is often a choice whether extension of space may be provided on one sector or the other; and if the space provided happens to be greater or less than the normal it can be readjusted in subsequent thinnings. It is this characteristic elasticity and readjustment which makes it possible to thin approximately correctly on the basis of tree classification (differentiation). Even when felled more heavily or lightly or against views most commonly held a thinning rarely results in ruination of the crop, though it has ruined the career of many a forester. An underthinned crop can be rethinned, which merely means a temporary change in the thinning cycle; and an overthinned crop almost always recovers its normality in time, which of course, varies with the extent of overfelling and results in reduced felling at the time of subsequent thinning. An abnormal thinning, unless verging on extreme limits, does not ruin a crop but certainly puts management to inconvenience.

Thinning cycle

Thinning being an age and number of trees relationship in a crop, it is apparent that thinning cycle has little to do with the regime. As long as sufficient trees are left to correspond with age (or diameter), thinnings may be carried out at any reasonable interval of time without affecting the regime. Thinning cycle is merely a matter of convenience with management; it may be constant and fixed at 5, 10, 15 or any other number of years, or it may vary with the age of the crop (or allotment to older periodic blocks). The varying cycle is more suitable silviculturally but it may not always be convenient to management.

Mechanical thinnings

Mechanical thinnings have come into greater prominence during recent years. It is another sign that the silvicultural thinning is not properly understood. Even the mathematical basis of thinnings lends no support to mechanical thinnings. As has been seen, thinnings are characterized by elasticity in space and pattern while mechanical thinnings inherit rigidity. In so far as they are incapable of taking advantage of accidents to trees both good and bad (such as for example trees resulting from exceptionally good seed or growing on exceptional good bits of ground or damaged by any of the adverse factors such as wind, snow, fire fungus, insects etc.) which is possible under the laws of average development, mechanical thinnings even when done at an early age are a complete negation of silvicultural thinnings. On account of the long period available for rectification, a much greater

latitude is permissible in the spacing of trees in young crops and should be taken full advantage of to remove badly formed trees, rather than make a mechanical thinning.

Silvicultural requirements of a crop

Talking of a silvicultural thinning, one is reminded of the most commonly used phrase, "the silvicultural requirements of the crop". Actually it has been the most misused phrase in connection with thinnings and covers all cases where a junior's marking is condemned and a senior's justified. "The silvicultural requirements of a crop" is a meaningless phrase unless one knows what average tree is to be developed. As a matter of fact, there is nothing natural or silvicultural about regimes and grades in the same sense as there is about the extent of, say, a regeneration felling.

Methods of thinning

What has been said in the preceding paragraphs forms the basis not only of the ordinary thinning but of all other methods of thinnings. These can be classified into two categories:—

(A) Rational (or mathematical), based on thinning regimes, such as
- (1) Volume method
- (2) Basal area method
- (3) Number of stems
- (4) Spacing number
- (5) Thinning degree and

(B) Empirical, based on tree classification and grade such as
- (1) Ordinary thinning (including mechanical thinning)
- (2) Crown thinning
- (3) Free thinning
- (4) Maximum thinning
- (5) Advance thinning (Craib)

With regard to rational systems it has been seen already that treatment (regime or numbers) determine development and growth of crops, and if the number and any one item of growth (*i.e.* average dimension) or even two items of the latter are known, then a complete picture of the crop and the treatment it has received can be drawn. Any two of the following items can therefore be used to determine the regime of thinnings.

1. Age.
2. Numbers (spacing)
3. Length { *a.* height of tree; *b.* length of crown
4. Width { *a.* diameter of stem (d.b.h.); *b.* diameter of crown
5. Area .. { *a.* basal area; *b.* crown spread
6. Volume of tree.

Many combinations are theoretically possible, as even a and b in the same group may also be combined, and several have been tried, but numbers and diameter (at breast height) are the easiest to work with, and it is preferable too that one of the items should be numbers. As regards the empirical systems their basis is exactly the same, that is the restriction of competition or the approach of competition and consequent suppression at a certain level and the development of the crop is just a function of the numbers. There is however one little difference in detail. In the case of ordinary thinning and also the advance thinning the development of the crop is gradual, resulting from the removal of the least wanted trees, while in the case of others there is a jump, which results in the ousted and unspaced being ignored from the point of view of competition as if they did not exist and the removals are confined to the poorer of the rest. After the jump the development is again gradual.

Dominance versus freedom

As mentioned previously, every attempt has been made in this thesis to maintain the form and figure of past experience, even at the risk of fresh and original ideas being interpreted as more changes in nomenclature, but whatever changes have been made they were necessitated by the complete change of outlook. Take for example the most conspicuous case of dominant and spaced trees. For the development of crops, dominance has been the master factor in the minds of foresters, the world over, for almost a century. What is actually best for crop development, as has been proved in the case of human community, is not dominance but freedom of development, restricted of course in the general interest of the entire crop, but with a compensating guarantee of freedom from four fears (want of light, want of air, want of water and want of salts).

What a tree growing in a crop needs, irrespective of its tendencies as an individual, is not dominance but freedom in space, restricted but sufficient to permit of its development like that of a respectable citizen, into an average tree.

The desirability of retention of a tree in a crop, depends on the extent to which it has achieved or been given this *freedom*, some that exceed the limit should gradually but firmly be brought back to the normal, but those that become a nuisance to their respectable neighbours through excessive freedom (like the wolf tree) become eligible for removal rather than retention.

Lest the change of outlook may be considered merely a sign of the times, trees with space about that of an average tree have not been called "free" as opposed to "dominant", but as the change of outlook is an urgent necessity and is facilitated by giving up the use of words associated with previous ideas a new, scientific, easy and expressive name, free from sentiment, has been found in the word "spaced".

NOTICE

A short history of the Assam Forest Service 1850—1945, by H.P. Smith, B.A. (Cantab.), B.A. (Oxon.), C.I.E., I.F.S., and C. Purkayastha, B.A., I.F.S. (Diploma), is available for sale by the Conservator of Forests, Assam, Shillong P.O., at a price of Rs. 2-4-0 per copy in addition to V.P.P charges.

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SINGLE STEM SILVICULTURE*
(THINNING IN TEAK PLANTATIONS)

By K. P. Sagreiya, I.F.S.
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SUMMARY:—Describes how the normal N/D curve could be used as a guide (a) to thin teak plantations and (b) to measure and control the "degree" of thinning.

The practice of *single stem silviculture* in teak plantations is comparatively easier because :—

(i) the range of size variation in the crop is small, as all 'stumplants' start with more or less equal vigour ;
(ii) the localities selected for planting are of a uniformly good quality ; and
(iii) the crop is uniformly stocked.

The following procedure is suggested :—

Thinnings in the juvenile stage

As soon as the plantations are about to close up, the adjacent stems begin to compete with one another for growing space. Thinning out of the crop in the interest of the best stems therefore becomes necessary. Unless these operations are carried out at the right time and to the correct intensity, the money returns from the plantations are likely to be seriously affected.

At this stage, stems are still growing with side branches more or less throughout their length, without any well-defined crowns, and 'grade' thinnings cannot be carried out. The effects of site factors are also not noticeable. It is, therefore, suggested that crops should be thinned when they have attained a top height of 30 feet, so as to reduce them to about 600 best stems as uniformly spaced as possible. Uniform spacing should be given greater weight than stem quality. In plantations started 6 ft.×6 ft. square planting, *i.e.* with 1,210 plants per acre, the alternate diagonals may first be marked for *retention* and then for every badly shaped stem in these diagonals the best of the four stems around it that are marked for *thinning* may be selected for retention, subject to the proviso that four stems in a square (6 ft.×6 ft.), or four in a line 6 feet apart should as far as possible be avoided.

The second thinning should similarly be carried out when the top height is 40 feet.

Under divisional practice, instead of top height, the *average height of the dominant stems* could safely be used. The dominant stems attain the heights of 30 and 40 feet earlier in better localities than on poorer localities. Roughly the time taken is as under :—

Table I—*Crop Height by Site Quality and Age.*

Average height in feet of dominant stems.	Age for C.P. Site Quality.			
	I	II	III	IV
30	4	6	10	15
40	8	12	20	30

Thus quality II patches will need the first thinning in the 6th year, whereas quality III patches that usually occur in a belt all round these will not be due for thinning till the 10th year. If it is at all practicable these patches should be thinned at the respective ages, because both *premature* as also *delayed* thinnings can do lasting harm to the crop. Or else, as a *via media* the entire crop may be thinned at the average optimum age, *i.e.* in the 8th year in the example under consideration. To make due allowance for site quality, the number of stems left in quality II patches should be a little less than 600, and a little more than this in quality III patches.

As the best stems do not yet declare themselves and as eventually not more than 30 to 50 trees per acre are needed, the aim in these juvenile stage thinnings should be to obtain uniform stocking by retaining even somewhat inferior stems to give optimum freedom (not more nor less) to the best stems that are to survive to the end of the rotation.

If the 'stumplants' have thrown out more than one shoot, all but the best should be carefully cut back at the earliest opportunity.

*For the first article on the subject see *Indian Forester* for November 1946.

Abnormally large stems (wolves or *bhaloos*) should also be removed, and the elites carefully pruned at least to a height of 12 feet using pruning saws.

Thinnings in the Adult stage

By the time the dominant stems have attained a height of 40 feet, the factors of locality begin to assert themselves to an extent sufficient to make quality class differentiation noticeable. Hereafter the crop height increases more rapidly the better the site quality. It can, therefore, no longer be used as an index for determining the dates of subsequent thinnings. Variation in the size and quality of stems due to micro-edaphic, environmental and genetic differences also become more pronounced, and as the crop has already been reduced to 300 stems per acre, it becomes imperative to examine each stem on its merits even more carefully than hithertofore, both as regards its quality as also its position, and then decide which of them are to be retained and tended. This may be done in a variety of ways depending on the intensity of management. Three methods are described. The first is the most satisfactory from the silvicultural-cum-management point of view and is therefore recommended for *value-per-acre* sample plots. The other two methods are less satisfactory but suitable for working plan prescriptions.

Method I

Cycle.—Thin up to two-thirds rotation at intervals of—

5, 10, 15 or 20 years
according as the age at the preceding thinning was—
20, 21-40, 41-60, or 60 years.

Intensity.—Determine the average diameter of the dominant stems (this will be larger the better the site-quality) and then retain as elites the best stems as uniformly spaced as possible in accordance with the following table, taking care to give slightly less or more growing space to individual elites which have a smaller or larger diameter than the average for the crop. The departure from the normal N per acre should not be allowed to be more than 10 per cent :—

Average diam. of elites.	N per acre (after thinning)
Inches.	No.
5	220
6	160
7	125
8	100
9	90
10	82
11	75
12	70
13	64
14	59
15	54
16	50
17	40
20	30

Method II

Cycle.—Thin up to two-thirds rotation age, at the ages of 10, 20, 30, 40, 60 and 80 years.

Intensity.—Determine the site quality class from the All India Teak Yield Table and then retain as elites the best stems as uniformly spaced as possible in accordance with the following Table.

Tabe III—*Age vs. Stems per Acre by Site Quality Classes.*

Age.	Stems per acre for C.P. Site Quality Class.			
	I (>90 ft.)	II (70-90 ft.)	III (50-70 ft.)	IV (40-50 ft.)
10	175	*	*	*
20	100	175	*	*
30	75	100	175	*
40	50	75	100	175
60	40	50	75	(100)
80	30	40	(50)	(75)

*Juvenile stage when the crop is to be thinned on top height basis.

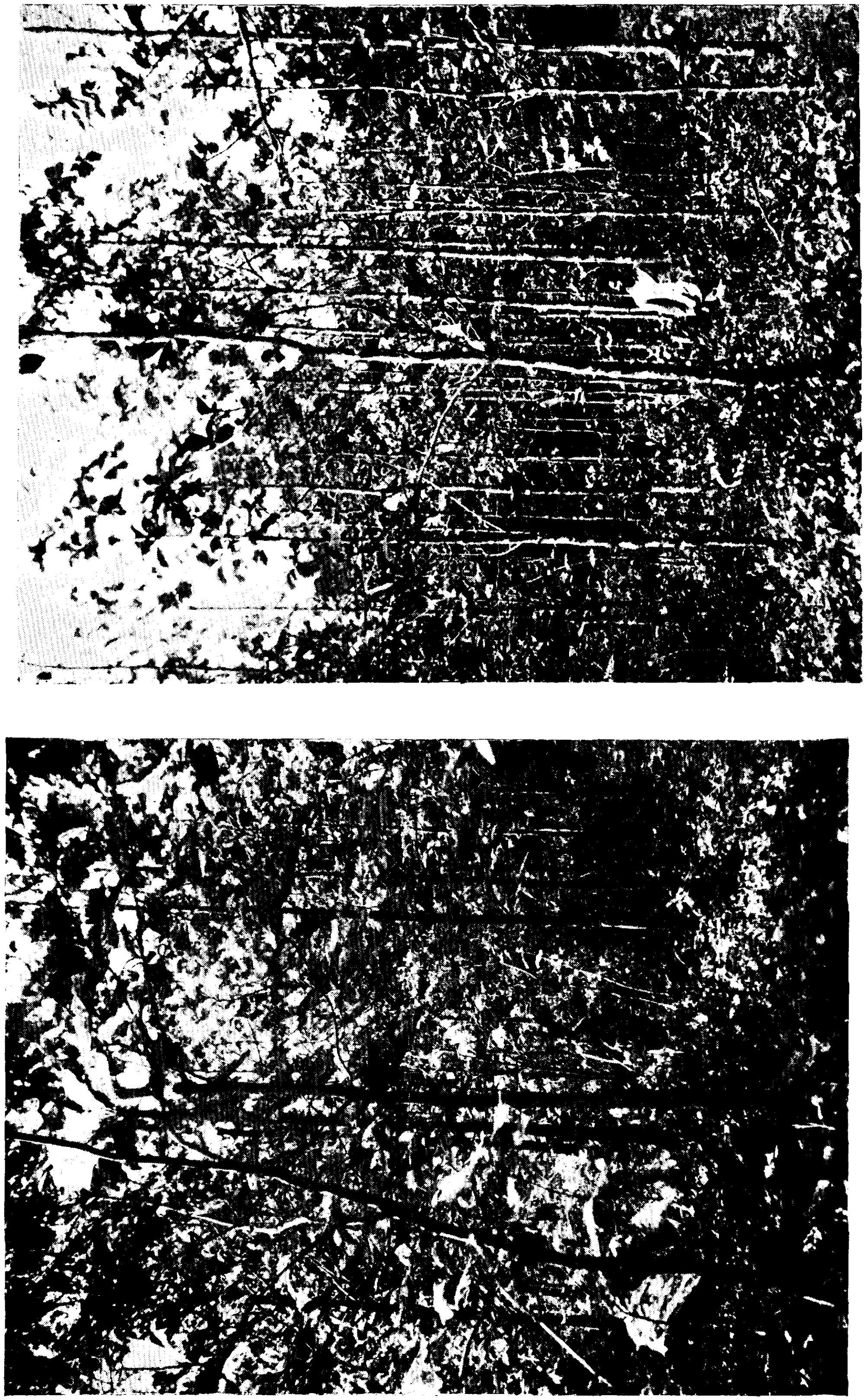
( ) Thin only if the crop is less than two-thirds rotation age.

Method III

Cycle.—As under Method II.

Intensity.—Retain as elites the best stems giving them the optimum growing space in accordance with the formula—

$$S' = (D_1'' + D_2'') + 6$$



Vertical Competition.

where S′ is the distance in feet between adjacent elites of diameters D_1 and D_2 inches. The spacing should never be less than S−2 feet and if it is actually more than S+2 feet an intermediate stem should be retained as a *courtesy* elite to prevent abnormal crown development of the elites. All suppressed trees should be left to side-prune the elites.

Note.—This is more or less the conventional 'rod' thinning except that it makes due allowance for the varying vigour of individual stems due to micro-edaphic factors.

Thinnings carried out by any of these methods will give far more satisfactory results than those obtained under the so called "common-sense" thinnings, and what is more important, over-thinnings will be avoided.

A plantation started in 1937 on C. P. Site Quality III at the initial spacing of 6.6 ft. ×6.6 ft. square planting *i.e.* 1,000 plants per acre was thinned on the lines indicated in 1946.

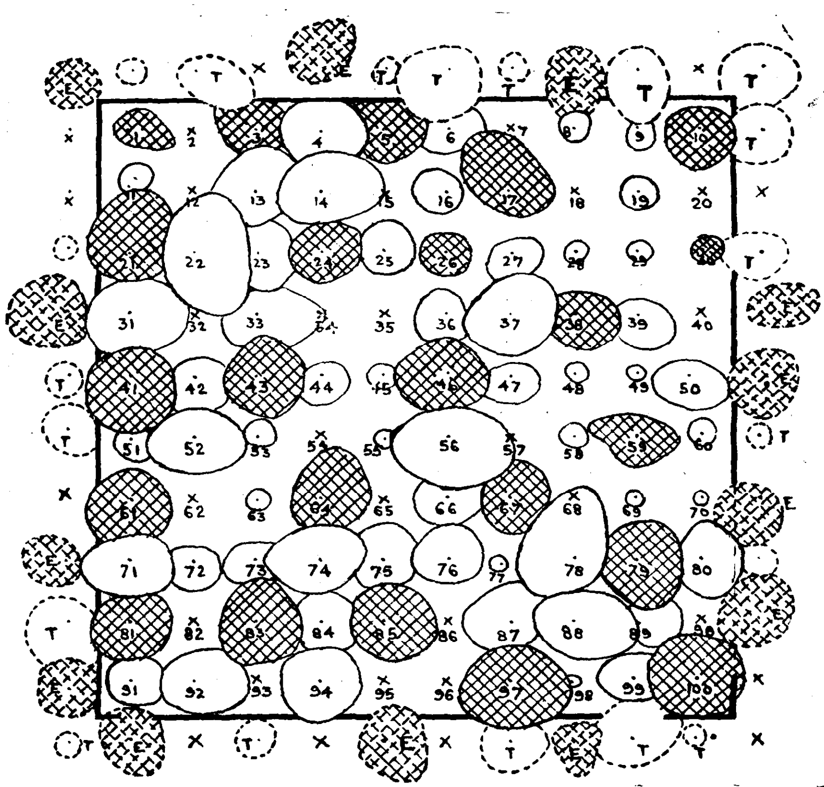


Fig. 1. Horizontal Competition

Plot area 66′×66′ *i.e.*, 0·1 acre.

Stems retained shown with a cross hatch.

No. of Stems	Before thinning	100
	After thinning	23
Crop diameter	Before thinning*	2·5″
	After thinning	4·0″

* Taking all the 100 stems.

Figure 1 above shows the horizontal competition in the stems standing over a plot of 0.1 acre (66 ft.×66 ft.) before and after thinning.

The particulars of stems are given in the statement in appendix on pages 327-329.

Plate 26 shows the appearance of the crop (vertical competition) before and after thinning.

Figure 2 below shows the Normal N. D. & S correlation.

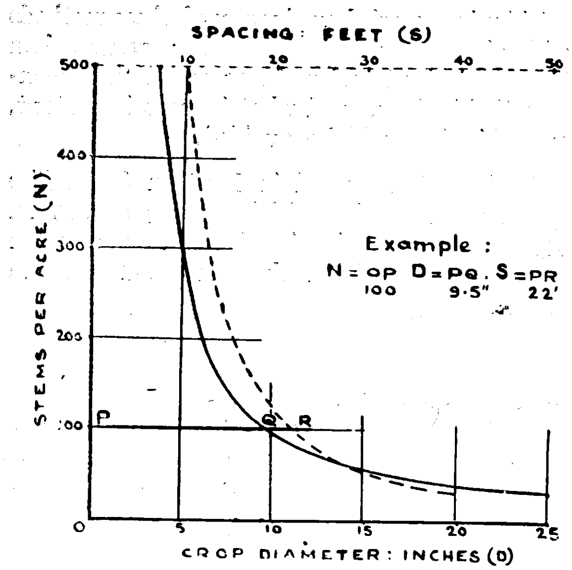


Fig. 2. Normal N. D. & S. Correlation.

Measure and Control of Thinning 'Degree'

The normal N/D curve can with advantage be utilised to statistically express the degree of heaviness or lightness of a thinning at any time and thus it is possible to maintain a set of plots, thinned throughout their life to specified degrees. The manner in which this may be done is illustrated in Figure 3 below :

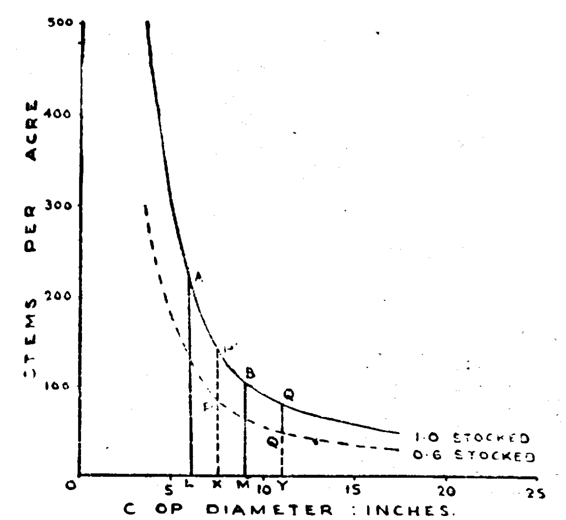


Fig. 3. Measure and Control of Thinning 'Degree'

Suppose two plots, X and Y, are to be maintained, plot X always thinned *normally*, and plot Y always thinned to a specified degree of heaviness.

Let the condition of plot X after the first normal thinning be represented by the point A on the normal N/D curve, and let the point P represent the condition of plot Y after it has been thinned to the requisite degree of heaviness. Then it is obvious that if the thinnings have been properly carried out, *i.e.* the best stems have been given the optimum growing space, plot Y, which is heavily thinned, will contain a fewer number of stems per acre than plot X. Its crop-diameter will also be greater because the smaller stems would have been removed when carrying out the heavier-than-the-normal thinning.

Draw the ordinates AL and PX, and produce the latter beyond P to meet the normal N/D curve at P′. Then the degree of heaviness of the thinning in plot Y could be expressed by the fraction PX/P′X, where PX is the actual number of stems per acre in plot Y, and P′X is the theoretical number of stems per acres in plot X when it attains a crop-diameter equal to that of plot Y after the first heavy thinning, namely OX. In the illustration, the fraction PX/P′X has been taken as equal to 0.6. If the normally thinned plot X is considered as '1.0 stocked' the heavily thinned plot Y can be referred to as '0.6 stocked'.

Now suppose that after the second normal thinning has been carried out when it just became due, the condition of the plot is represented by the point B. (By hypothesis this point will be on the normal N/D curve).

Then the problem reduces itself to determining the condition of plot Y after the second heavy thinning has been carried out, when it is just due, and to the same degree as the first thinning. Suppose that after such a thinning the condition of the plot is represented by the point Q. (i.e. N per acre=QY, and crop-diameter = OY). Then, as before, the degree of this thinning is measured by the fraction QY/Q′Y where Q′Y is the theoretical number of stems per acre in the normally thinned plot X, when it attains a crop-diameter of OY.

Now, if this second heavy thinning in plot Y were of the same degree as the first, then PX/P′X will be equal to QY/Q′Y. In other words if an N/D curve were to be drawn with its ordinates 0.6 times those of the normal N/D curve, the point Q will lie on this curve. Conversely, therefore, if the second thinning is so manipulated that for the particular crop-diameter obtained after thinning, the number

of stems per acre corresponds to the '0.6 stocked' curve, the crop would have been thinned to the same degree as at the first thinning.

In other words, whenever a plot is required to be maintained thinned to a specified degree, throughout its life, all that is necessary is to construct, after the first thinning, the appropriate N/D curve, and carry out all subsequent thinnings, when they become due, so as to satisfy this curve.

It is obvious that for thinnings *heavier* than the normal, the N/D curves will lie entirely in the *free growth* zone, and *per contra*, for thinnings lighter than the normal the N/D curves will lie entirely in the *suppression* zone.

When carrying out these thinnings it should be borne in mind that a crop can be thinned to satisfy a particular N/D curve in more ways than one, namely either to a smaller crop-diameter (and hence larger N per acre) or *vice versa*. From the point of view of maximum final-value-yield per acre, invariably the thinning which gives the bigget crop-diameter will be found to be the best. In comparative thinning plots maintained for preparing money yield tables, therefore, the aim should always be to obtain the biggest possible crop-diameter after each thinning.

It will be readily seen that when thinning 'degrees' are controlled in the manner indicated, the various plots under comparison need not be thinned simultaneously, which is tantamount to forcing the crops to depart from their natural tendency to respond to the desired degree of thinning, because the successive thinnings in lightly thinned plots will be unduly delayed whereas heavier thinnings will be carried out prematurely. The thinnings in the various plots can be carried out whenever they are just due and thus the full effects of different degrees of thinnings can be studied.

APPENDIX

Particulars of Stems

Stem No.	Diameter	Height	*Crown class	Bole quality	Treatment
	Inches	*Feet*			
1.	1.4	16	D	Bad	Retained.
2.	..	..	X	..	..
3.	3.7	30	d	Good	Retained.
4.	4.8	40	D	Good	Thinned.
5.	4.1	36	d	Good	Retained.
6.	3.1	25	d	Bad	Thinned.
7.	..	..	X	..	..
8.	1.5	15	s	Bad	Thinned.
9.	2.5	25	d	Fair	Thinned.
10.	3.3	30	D	Good	Retained.
11.	1.0	20	s	Bad	§Thinned.
12.	..	..	X	..	..
13.	3.7	30	d	Bad	Thinned.
14.	3.6	30	D	Fair	Thinned.
15.	..	..	X	..	..
16.	0.3	7	D	Bad	Thinned.
17.	3.7	30	W	Good	Retained.
18.	..	..	X	..	..
19.	1.7	16	d	Bad	Thinned.
20.	0.5	5	m	Bad	Coppiced.
21.	4.3	38	D	Good	Retained.
22.	7.5	37	W	Fair	Thinned.
23.	4.0	33	d	Good	Thinned.
24.	4.5	42	D	Good	Retained.
25.	2.9	25	d	Bad	Thinned.
26.	2.1	25	d	Fair	Retained.
27.	2.1	22	d	Fair	Thinned.
28.	1.1	10	s	Bad	§Thinned.
29.	0.5	5	s	Bad	Thinned.
30.	2.5	22	d	Fair	Retained.
31.	5.7	42	D	Fair	Thinned.
32.	..	..	X	..	..
33.	3.6	28	d	Bad	Thinned.

*D = Dominant, d=dominated, s = suppressed, X = missing
W = wolf, m = moribund.
§Could be left to side-prune the elites.

Particulars Of Stems—contd.

Stem No.	Diameter	Height	*Crown class	Bole quality	Treatment
	Inches	*Feet*			
34.	0.6	8	m	Bad	Coppiced.
35.	..	..	X	..	..
36.	2.2	25	d	Bad	Thinned.
37.	3.9	32	D	Bad	Thinned.
38.	2.9	25	d	Fair	Retained.
39.	1.6	19	d	Fair	Thinned.
40.	..	..	X	..	..
41.	4.6	38	D	Good	Retained.
42.	3.7	35	d	Fair	Thinned.
43.	4.6	32	D	Fair	Retained.
44.	3.5	32	d	Bad	Thinned.
45.	1.5	15	s	Bad	§Thinned.
46.	4.7	38	D	Good	Retained.
47.	2.0	25	d	Fair	Thinned.
48.	0.5	7	s	Bad	§Thinned.
49.	0.6	8	s	Bad	§Thinned.
50.	2.5	19	D	Bad	Thinned.
51.	1.7	16	s	Bad	§Thinned.
52.	4.6	38	D	Good	Thinned.
53.	1.5	19	s	Bad	Thinned.
54.	..	..	m	Bad	Coppiced.
55.	1.4	10	s	Bad	Thinned.
56.	5.3	35	W	Good	Thinned.
57.	..	..	X	..	..
58.	3.5	19	s	Bad	Thinned.
59.	3.2	25	d	Bad	Retained.
60.	1.5	15	s	Bad	Thinned.
61.	5.1	40	D	Fair	Retained.
62.	0.6	6	m	..	Coppiced.
63.	2.2	12	s	Bad	Coppiced.
64.	3.5	30	d	Good	Retained.
65.	..	..	X	..	..
66.	3.9	37	d	Fair	Thinned.

*D = Dominant, d=dominated, s = suppressed, X = missing.
W = wolf, m = moribund.
§[illegible] be left to side-prune the elites.

Particulars of Stems—concld.

Stem No.	Diameter	Height	*Crown class	Bole quality	Treatment
	Inches	*Feet*			
67.	3.6	30	d	Good	Retained.
68.	..	..	X	..	..
69.	0.5	5	s	Bad	§Thinned.
70.	0.5	10	s	Bad	Thinned.
71.	5.5	40	D	Good	Thinned.
72.	4.3	30	d	Bad	Thinned.
73.	3.5	25	s	Bad	Thinned.
74.	6.0	42	D	Good	Thinned.
75.	3.7	35	d	Good	Thinned.
76.	3.3	30	D	Fair	Thinned.
77.	0.5	18	s	Bad	§Thinned.
78.	5.5	45	W	Good	Thinned.
79.	3.8	30	D	Good	Retained.
80.	4.1	30	D	Fair	Thinned.
81.	5 9	42	D	Good	Retained.
82.	..	..	X	..	..
83.	4.1	40	D	Good	Retained.
84.	4.0	38	d	Good	Thinned.
85.	5.2	40	D	Fair	Retained.
86.	..	..	X	..	..
87.	4.6	40	d	Bad	Thinned.
88.	4.7	40	D	Good	Thinned.
89.	2.7	32	s	Bad	Thinned.
90.	..	..	X	..	..
91.	4.6	30	D	Fair	Thinned.
92.	5.1	45	D	Good	Thinned.
93.	..	..	X	..	..
94.	4.6	38	D	Good	Thinned.
95.	..	..	X	..	..
96.	..	..	X	..	..
97.	5.4	45	D	Fair	Retained.
98.	0.5	8	s	Bad	§Thinned.
99.	2.7	32	d	Bad	Thinned.
100.	6.0	40	D	Fair	Retained.

*D = Dominant, d=dominated, s = suppressed, X = missing.
W = wolf, m = moribund.
§[illegible]

STATEMENT OF WILD ANIMALS SHOT IN SOME OF THE INDIAN

All India Serial Number.	Species.	Ajmer-Merwara.	Assam.	Bengal.	Bihar.
1a	Tiger	..	52	22	5
1b	Tigress	..	13	18	3
2	Leopard or panther	1	51	39	..
3	Wild cats-(species to be given, if known) ..	..	35	8	1
4	Lynx	..	..	..	..
5	Hunting leopard or cheetah ..	..	6	..	..
6	Hyena	..	..	..	..
7	Wolf	..	..	..	1
8	Wild dog	..	69	4	1
9	Martens	..	..	..	..
10	Ratel	..	..	..	..
11	Brown bear	..	..	..	..
12	Himalayan black bear	..	2	2	..
13	Malayan bear	..	..	..	..
14	Sloth bear	..	63	8	4
15	Wild elephant	..	24	14	..
16	Rhinoceros (species to be given) ..	..	4 (*R. unicornis*)	..	..
17	Gaur or bison	..	..	..	2
18	Goyal or Mithan	..	5	..	..
19	Banting or tsine	..	..	..	..
20	Wild buffalo	..	5		..
21	Urial or shorpu	..	..	..	..
22	Bharal or blue Sheep	..	..	..	..
23	Ibex	..	..	..	..
24	Markhor	..	..	..	..
25	Tahr	..	..	..	..
26	Nilgiri wild goat or Nilgiri ibex ..	..	..	..	..
27	Serow or Himalayan goat antelope, yamu	..	..	3	..
28	Goral	..	19	6	..
29	Nilgai or blue bull	3	..	..	1
30	Four-horned antelope	..	..	..	..
31	Black buck	..	..	..	..
32	Indian gazelle or chinkara ..	..	..	..	..
33	Barking deer or kakar	..	409	193	8
34	Kashmir deer or hangul	..	..	..	..
35	Swamp deer or gond or barasinga ..	..	17	..	..
36	Brow-antlered deer or thamin ..	..	..	..	..
37	Sambar	..	54	35	11
38	Cheetal or spotted deer or axis deer ..	..	..	988	12
39	Hog deer or para	..	74	40	..
40	Musk-deer	..	..	..	..
41	Mouse-deer	..	..	..	..
42	Pangolin	..	..	..	..
43	Crocodile (muggar)	..	..	911	..
44	Gharial	..	..	..	..
45	Python	..	9	4	..
46	Others (species to be given) ..	2 (pigs)	883 (pigs 220, hares 10, porcupines 116, wild monkeys 237, apes 32, squirrels 243, jackals 25)	364 (pigs 260, monitar lizard 36, hares 27, porcupines 1, others 40)	24 (pigs 15, jackals 2, hares 7)

PROVINCES AND STATES DURING 1945-46.

Bombay.	C. P. & Berar.	Coorg.	Madras.	Orissa.	Punjab.	Sind.	U. P.	Jammu & Kashmir State.
12	57	11	10	5	..	..	75	..
6	18	..	..	..	..	..	40	..
30	62	25	14	5	18	..	60	3
..	2	..	9	..	..	..	14	7
..	..	..	..	..	..	..	..	..
..	..	..	3	..	..	..	..	..
..	9	..	..	..	1	..	9	..
..	..	..	..	..	2	1	..	16
1	12	2	26	2	..	..	6	..
..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..
..	..	..	..	3	1	..	..	1
..	..	..	3	..	3	..	14	14
..	..	..	..	..	..	..	..	..
2	27	..	..	..	..	..	7	..
4	..	..	2	3	..	..	..	..
..	..	..	..	..	..	..	..	..
8	5	..	9	..	..	..	..	..
..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..
..	..	..	..	..	35	..	..	3
..	..	..	..	..	11	..	..	3
..	..	..	4	..	1	..	..	3
..	..	..	..	..	..	..	..	2
..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..
..	..	..	..	..	1	..	..	..
..	..	..	..	..	2	..	10	..
1	93	..	..	2	11	..	121	..
..	6	..	..	..	..	..	4	..
..	6	..	3	..	..	..	10	..
1	23	..	..	..	..	..	5	1
2	61	6	29	7	..	..	48	..
..	..	..	..	..	..	..	..	2
..	4	..	..	..	..	..	24	..
..	..	..	..	..	..	..	..	..
3	113	4	18	15	1	..	107	..
4	139	28	12	5	2	..	230	..
..	..	..	..	..	..	..	14	..
..	..	..	1	..	3	..	..	..
..	..	..	..	..	8	..	..	..
..	..	..	..	..	..	..	..	..
..	..	..	..	1	..	..	4	..
..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	5	..
446 (wild pigs)	275 (pigs 249, hares 4, other deer 16 wild boars 6)	4 (wild boars)	31 (jungle sheep 2, wild boars 12, pigs 9, porcu-pine 1, rabits 7),	5 (wild pigs)	161 (pigs 104, jackals 25, hares 20, foxes 11, naying 1)	177 (pigs 139, pharas 33, foxes 5)	598 (otters, porcupines pigs, etc.)	85 (otters 5, ammon pamir sheep 6, fox 40, jackals 34)

Pathological Notes: No. 3*.

AN UNRECORDED PARASITE OF TEAK (*TECTONA GRANDIS* Linn. f.) REPORTED FROM DEHRA DUN, U.P.

By K. D. Bagchee

(*F. R. I., Dehra Dun.*)

In September 1940, Mr. M. V. Laurie, I.F.S., the Central Silviculturist at that time, drew the writer's attention to a group of diseased teak trees in a young plantation 10 to 12 years old in the demonstration area of the Forest Research Institute, New Forest, Dehra Dun. This plantation was established on rich loamy soil with bouldery subsoil the land having previously been under cereal crop cultivation, 4 or 5 acres in area. The trees were raised from stump planting, the plots being arranged in 5 small compartments, each measuring about 0.9 of an acre. The seeds used for raising the seedlings were from Burma and also local. The trees were about 20 to 25 feet in height and 2 to 2½ ft. in girth, apparently very healthy and vigorous. When the disease was first reported the plantation had been thinned 3 or 4 years earlier.

All this time about half-a-dozen trees had already died and more than a dozen were noticed to be drying up from the top downwards all the leaves appearing yellow. The topmost branches were shedding leaves in the middle of September, much in advance of the usual time as in Dehra Dun the normal time for leaf-fall is the end of November. The attacked trees were scattered although it was noticeable that the disease showed itself more in the centre of the plot where the plantation was dense.

This was the first apparent symptom of the disease. Closer examination showed extensive scars on the tree stems at various heights from 6 to 12 ft. above the ground. These scars had a water-soaked rotten appearance. There was a profuse exudation of gum and tannin from the affected parts which, on drying, showed both vertical and transverse cracks, and the bark could easily be peeled off with a blunt knife (*plate* 27, *figs. A,B,C, and D*). The scars were oblique and spindle shaped, in size 4 to 6 in. × 10 to 12 in. The callus formation along the edges signified that the disease must have been there for at least more than two growing seasons, the initial stages having been overlooked. In a few trees it was noticed also that the dead bark in the inner part of the scar had fallen off in the same manner as scales, and a callus growth had effectively stopped further spread of the infection (*plate 27, fig. D.*). Some of the trees on the outer boundary of the plot on the south-west had fully recovered after the initial attack, but the disease seemed to be increasing towards the shady side of the northern boundary of the plot facing another experimental forest of *A. catechu*.

While touring in the Gorakhpur Division in November 1944 the writer inspected the All-India teak seed origin experimental plots, and came across some diseased poles in Plot No. 34 showing identical symptoms of canker. These trees were raised from the seeds brought from Nilambur. There were, however, no conidiospores or perithecia on the bark. A few trees had died of the disease, but most had recovered, the wound having been gradually healed by the formation of the callus layer. This observation gave further stimulus to the study of the disease. While touring in Malabar in connection with the study of wood-rotting fungi the writer had the opportunity of examining numerous teak plantations of various ages from saplings to poles in Nilambur, Wynaad and Coorg, but nowhere was this disease noticed. It is possible that the conditions under which teak grows are quite different in the North and the South India. Alternatively it can be said that because of the short time at the writer's disposal the range of observation was necessarily limited, and hence the disease in the south could not be spotted. It is obvious, however, that the disease is not a widespread one in the south if it exists at all.

The Pathogene

Microscopic examination of the diseased tissue revealed the presence of thin hyphae 0.75 to 1.25μ wide, multinucleate with thin

*No. 2 appeared in the issue of January 1945.

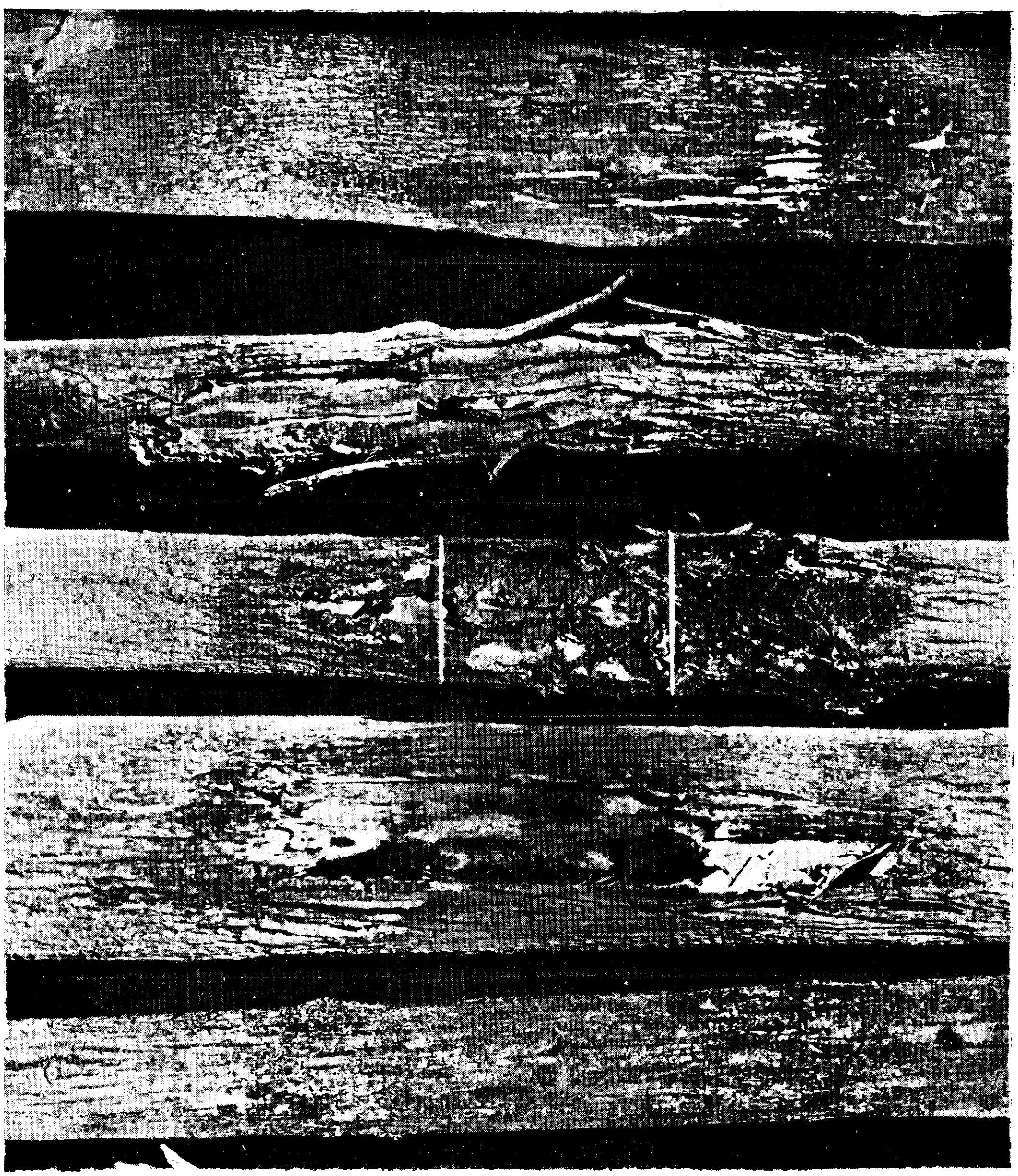
A

B

C

D

E



Sections of teak stems showing different stages of canker formation, from the initial stage of infection (Fig. A) to complete girdling of the tree (Fig. B and C). Fig. D shows partial healing of the canker by Callus formation, 8 months after the thinning of the plantation. Fig. E shows a stem which was inoculated with the culture of **Hypomyces haematococcus** (**Fusarium** stage). The scattered white spots on the stem indicate masses of **Fusarium** spores. 10-1-8.

Fig A

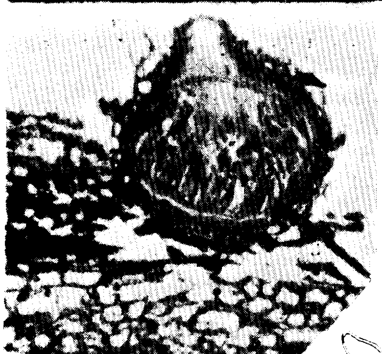
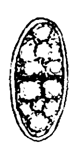


Fig C

b



c

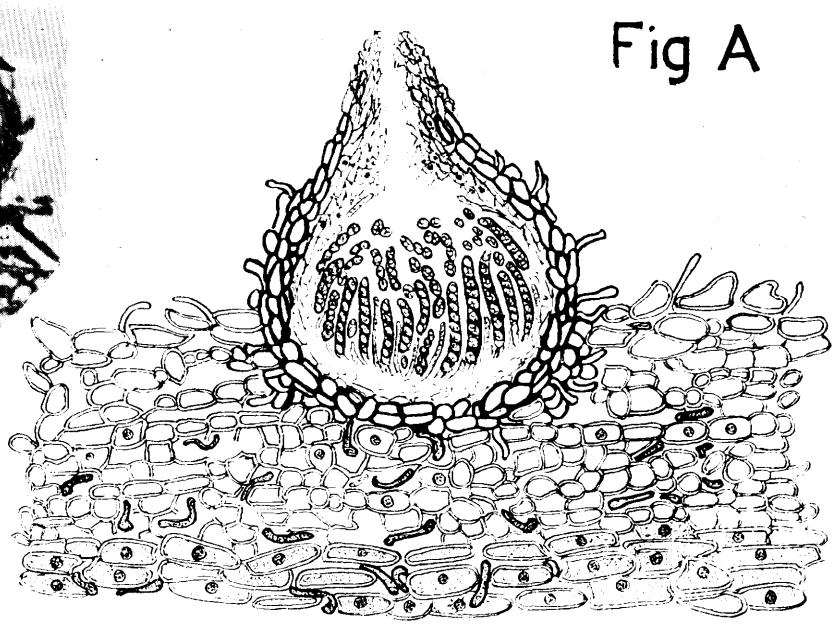


Fig B(a)

Fig. A. The stem shown in Fig. C in natural size. The two big patches contain numerous garnet coloured perithecia.

Fig. B. Drawing of the perithecia (a) on the bark with haustria lodged in the cambial cells. X 130, (b) an ascus, X 580 (c) an ascospore, X 1,300.

*Fig. C. Section of a perithecium (microphotographed) X 40

* The microphotograph was taken by Mr. K. N. Tandon M.Sc. Assistant

partition walls. They were abundant in the phellogen and cambium, and had also penetrated in the companion cells of the phloem where the width was $2 \cdot 5\mu$ approximately.

There were masses of conidiospores, mostly 5-septate, but also varying from 3 to 7, on the external bark at this stage. The 5-septate spores measured from 5.0×6.5 to $5.0 \times 8.5\mu$.

After 4 weeks, from the middle of October to the beginning of November pink-coloured minute perithecia were formed in the cracks and cavities of the bark, the colour changing to bright garnet on maturity, and many more warty perithecia appeared, scattered as well as in groups (*plate 27, fig. C and plate 28, fig. A*).

The perithecia were onion shaped [*plate 28, figs. B.* (*a*) *and C*] with small ostioles the size being $75 \times 120 \times 10$ to 15μ with 8 uniseriate, hyaline, bi-celled, oval, feebly striated spores size 10 to $13.5 \times 7.5\mu$. [*plate 28, fig. B.* (*a, b, c*)].

The fungus was isolated from the diseased tissues of the bark and sapwood and from the conidiospores (*Fusarium*) which germinated easily. Culture from ascospores was also established in October 1945. All these cultures agreed in colour and morphology when grown in Brown's media, but later on the ascospore culture weakened considerably and finally died out after producing sickle-shaped conidiospores (*Fusarium* stage). The spores were mostly 5-septate with a greater variation than the conidiospores collected from the bark and measured 40 to 90×5 to 8μ (5-septate).

Experiments were conducted in July 1942 and 43 on two-year and three-year old plants of teak raised from stump cutting, by inoculation of conidiospores (*Fusarium*), also culture in synthetic ager media (Brown's media) on the young shoots (first internode), the inoculated twigs being kept moist (in celloidin sleeves) from 24 to 72 hours, both methods proving effective. Discoloration of the bark (*plate 27, fig. D*) was noticed within 15 days, gummosis after 6 weeks, lesions with vertical splittings of the bark appearing a few weeks later. Ten weeks later, in September, were seen sporebeds flesh to carmine-coloured. Out of the 36 plants inoculated, in 5 the leaders were girdled above the point of infection, but there was no formation of perithecia. The canker did not progress downwards and one of the two lateral buds lower down from the nodes became the leading shoot, the tree surviving the attack. Out of the 36 inoculated at the second node and collar region by wounding the bark, there was no apparent infection and the wound healed up after formation of callus during the next growing season. Although the experiments were repeated in the following year and the same results were produced they cannot yet be called conclusive in all the aspects. It, however, is proved definitely that the fungus being a parasite calls for immediate protective measures in the interest of this valuable species, widely cultivated in the moist zones of North India.

Identity of the Pathogene

Under the Martiella group(*Martiella-Fusarien*) Wollenwaber and Reinking have described* various species of Hypomyces, some in the conidial (*Fusarium*) and others in both the conidial and perithecial stages (Nectrial). Of the Hypomyces which have the perfect stage (*Perithecia*) the following three are comparable to the teak-canker fungus, namely.

(i) *Hypomyces haematococcus* (Berk. et. Br.) *v. breviconis* Wr. (*conidial stage Fusarium solani* v. *minus* Wr.).

(ii) *Hypomyces haematococcus* (Berk. et. Br.) Wr. Syn. (*conidial stage* resembling *F. solani* v. *striatum*).

(iii) *Hypomyces haematococcus* (Berk. et Br.) Wr. Syn. *Nectria haematococca* Berk. et. Br. *N. anisophila* Pic., *N. citri* P. Henn., *N. aspeiala* Rehm., *N. luteo-coceinea* Holm. *N. melanommatis* Syd., *N. Victoriae* P. Henn. (*conidial stage F. solani* v. *eumarti* Wr.).

Of these the fungus compares more closely with *Hypomyces haematococcus* (Berk. et. Br.) Wr. as regards the septation of the conidial spores which falls within the range of spore measurement and the perithecia and the ascospores with *Nectria haematococca* which are feebly striated.

The disease is a tropical one and has been recorded on dead or decomposing branches and fruits of various trees namely Adesmia,

**Die Fusarium,* Wollenwaber and Reinking, 1940.

Caesalpinia, Cinchona, Citras, Coffee, Murraya and Theobrama in the warmer areas of America, Asia and Africa. Whether this teak disease is identical with *F. solani* v. *eumarti* can only be decided by inoculation and cross inoculation of this fungus on cocoa trees. It has not been possible for the writer to conduct these experiments.

It is easy to control this disease by proper thinning, and opening out the forest to sunlight and air. In dense plantations where thinning is not possible the diseased trees should be sprayed with strong Bordeaux mixture 4-4-50, twice in the spring and twice in the autumn. This will control the disease if continued for 2 to 3 years when the trees are young. Once the trees have passed out of the pole stage the plantations should be properly thinned. This will check further recurrences of the disease.

The author is grateful to Dr. Bisby and Mr. Mason of the Imperial Mycological Institute, Kew, for kindly indentifying the fungus and Dr. Wiltshire for supplying the reference.

UNITED PROVINCES FOREST DEPARTMENT LEAFLET NO. 14—RESULTS OF TRIALS OF INDIGENOUS AND EXOTIC FODDER GRASSES UNDER BOTH AGRICULTURAL AND FOREST CONDITIONS, FROM 1939 TO 1945. COMPILED BY S. K. SETH, SILVICULTURIST, UNITED PROVINCES—18pp. PUBLISHED AUGUST, 1946.

The above set of experiments for yield of forage clearly shows that exotics even under agricultural conditions are not promising except possibly *Panicum maximum*, for large scale adoption. Indigenous grasses with two croppings in the rains and summer and winter croppings yield more than exotics from a single crop for the year under similar agricultural conditions and are obviously to be preferred.

The craze for exotics must cease on points if not on a technical K. O. The indigenous *sandhaur* grass (*Bathricola intermedia*), which is also hardy, has given the best results throughout, holding its place for yield in the trials for successive rain croppings as well.

The experiments under forest conditions further justify the prominence of *sandhaur* grass as established in the other series, though the yield in the former series is lower by about half. When cost figures enter into the calculation of production and supply on a commercial scale, *sandhaur*, under forest conditions, would probably be popularly accepted as profitable and generally possible to cultivate extensively.

The conclusions drawn regarding effect of shade on growth and yield of grass in *taungya* areas (forest conditions) are along accepted lines.

Weeding is not justified on cost and output considerations.

Observations on the possible production range from the extensive blanks in forests and village waste lands; and on the plans for gradual extension of *Sandhour, dub* (*Cynodon dactylon*), *bari jergi* (*Dichanthium annulatum*), and *chhoti jergi* (*Bothriochloa pertusa*) species in such blanks with suggestions for effective exclusion of coarser grasses and weeds detrimental to the useful varieties would be of great practical utility.

D.R.N.

EXTRACTS

A SIMPLE METHOD OF VOLUME-TABLE CONSTRUCTION

By Forrest C. Reed.

Forester, Weyerhaeuser Timber Company, Montesano, Wash.

This article and the accompanying comment suggest a simple method of volume-table construction that has given satisfactory results on the West Coast.

One of the problems of cruising is the recognition of variations in taper. Commonly these variations are judged either by eye or by measurement of a few sample windfalls. The former method is reliable only when used by the most discerning and experienced men. The latter is at best a crude rule of thumb because the few windfalls measured may not be representative of the group and because the taper per log increases as the diameter at breast height increases.

A volume table that accounts for the variations within d.b.h. classes and taper per log can be completed within one to three days by measurements in the nearest operation cutting timber similar in species, age, and site to that to be cruised. The cruiser makes a separate sheet for each 5.-inch class, as 18-22 inches, 23-27 inches, and so on. He then measures and averages the d.b.h. and the length and diameter of each log for 10 trees in each class. Thus in a stand of Douglas fir, 200 years old, on sites I and II, average figures for the 48-52 inch class are shown in the column headed "actual" in Table 1.

The next step is to convert the actual diameter at the top of each log to the corresponding diameter for a tree at the mid-point of the class in question, which in this case would be one with a d.b.h. of 50 inches. To do this for the first log, the form quotient of the tree is determined by dividing the d.i.b. at the top end of the first log by the d.b.h. and then multiplying this form quotient by the mid-point diameter of the class.

The diameter at the top of the succeeding log is then found by allowing the same taper found in the original measurements. Thus, for the first log in the 48-52 inch class, the adjusted diameter is $(35.9 \div 50.40) \times 50 = 35.6$ inches; for the second log it is $35.6 - 4.7 = 30.9$ inches; and so on. These new diameters are shown in the column headed "adjusted" in Table 1.

The measurements are now plotted on graph paper so as to duplicate the exact shape of the stem up to the last log. Lines are then drawn through these curves at intervals of the length logs are cruised, usually 32 feet, and for each 5-inch d.b.h. class the diameters at the end of each log are read. The resulting figures for the tree at the mid-point of the 48-52 inch group (50 inches d.b.h.) are shown in Table 2.

These taper data for all 5-inch classes are then placed on graph paper with d.b.h. horizontally and average taper of each log vertically. From these points curves are drawn from which average taper for any log beyond the butt log can be read. Since the form quotient (d.i.b. at top of first log divided by d.b.h.) seldom varies more than 2 per cent for the same species, age, and site, the various form quotients for the 5-inch classes are averaged.

With the form quotient and taper per log for each diameter class now known, construction of a volume table is a simple matter of determining the volume of each log, adding the volumes, and making a graph with d.b.h. horizontally and volume vertically. The volume for each 2-inch class is then read from the curves. Thus, for the 50-inch class the volumes by the Scribner rule are as follows:

Logs per tree	Volume, board feet
1	2,000
2	3,600
3	4,750
4	5,400
5	5,800

Volume tables made by this method check within 2 per cent of aggregate differences. The cruiser going into a new area can in one to three days make a volume table that will be both accurate and simple as a guide to his judgment. In most cases he would wish to spend at least one day familiarizing himself with local defect in logs anyway. Hence, at a cost of two additional days his accuracy and speed are improved to a point where volume estimates should be within 2 per cent of gross volume.

The writer using this method has cruised faller's strips running from 200,000 to 600,000 board feet that scale out consistently within less than 5 per cent of net water scale.

TABLE 1.—ACTUAL AND ADJUSTED MEASUREMENTS FOR LOGS IN THE 48-52 INCH CLASS.

	Actual	Adjusted
D.b.h., inches	50.4	50
First log		
Length, ft.	41	41
D.i.b., in.	35.9	35.6
Second log		
Length, ft.	41	41
D.i.b., in.	31.2	30.9
Third log		
Length, ft.	37	37
D.i.b., in.	26.2	25.9
Fourth log		
Length, ft.	32	32
D.i.b., in.	19.7	19.4

TABLE 2.—DIAMETERS AND TAPERS OF 32-FOOT LOGS IN A 50-INCH TREE.

Log	D.i.b.	Taper
	Inches	
1	37.3	..
2	32.5	4.8
3	28.2	4.3
4	22.7	5.5
5	15.5	7.2

COMMENT

Clement Mesavage[1]

The method of volume table construction followed by Mr. Reed is along the same lines described by Girard and Gevorkiantz[2]. I have checked the volume table which Mr. Reed used as an illustration of his method and find that the volume checks within 2 to 4 per cent of the volume secured with tables based on Douglasfir tapers compiled by Girard. Taper tables compiled by Girard were based on all of the Douglasfir trees that were measured by the Forest Survey in western Oregon and western Washington.

Whether or not Reed's method will work consistently in practice in different stands throughout the Douglasfir territory depends on whether or not logging operations are available in stands similar to those which must be cruised. Tree volume in trees of the same diameter class depends on the butt-log taper and the taper in the upper logs, both of which are very strongly correlated with merchantable height. For example, a 60-inch tree with 6 32-foot logs

[1]Forester, Southern Forest Experiment Station, New Orleans, La.

[2]Girard, J. W. and S. R. Gevorkiantz, Timber cruising. 160 pp. U. S. Forest Service. Lithographed. 1939.

ordinarily has a higher form class than a 60-inch tree with only 4 32-foot logs. Moreover, the 6-log tree will have less taper in the second, third, and fourth logs than the 4-log tree will have in the same logs.

If the stand of timber to which Reed's tables will be applied has approximately the same distribution of height classes as the stand from which his sample trees were taken, the total stand volume should check satisfactorily. However, if the distribution of height classes varies materially from the stands which furnished his sample trees the volume check might not be satisfactory, because the volume in the short trees will be overstated and the volume in the long trees will be understated.

There are two ways in which Reed's method of constructing volume tables could be improved : (1) by determining the form class by diameter and height classes, and (2) by compiling a set of taper tables by diameter and height classes. This would permit the cruiser to modify his table so that they would be applicable to any stand in the region, even though the distribution of height classes varied from area to area.

Any cruiser should be able, by taking advantage of logging operations, to train himself to recognize form class ocularly close enough for all practical purposes. If, in addition, he has a set of basic taper tables by diameter and height classes, he can readily prepare a satisfactory volume table for any stand.

Reed should be congratulated on his simple, practical method of volume-table construction, which, with the additional information indicated, will give entirely satisfactory results for any of the West Coast species.

—*Journal of Forestry*, Vol. 44, No. 3, March 1946.

RESEARCH ON LAMINATED WOOD

Investigations in Germany—Best Products from Beech Veneers

To find out the latest developments in the production of laminated wood was the object of a visit by Allied technical experts to Blomberger Holzindustrie plywood plant at Blomberg-Lippe, Germany, and the report of this and other investigations appears in "Wood Structural Research and Development" (F.I.A.T. Final Report No. 225, H.M. Stationery Office, 8s. 6d. net). During the investigations the experts interviewed Dr. Kraemer, research director of Blomberger Holzindustrie, reputed to be a foremost research worker in regard to laminated wood.

Wood v. Metal

Dr. Kraemer stated that the only basis on which wood can compete with metal for structural use is to provide a material which is essentially uniform throughout and for which moisture contents and minimum strength can be specified with certainty. Using such a material, a designer, even though inexperienced in the use of wood as a structural material, could properly utilise it in the same manner as he could use metal. By producing a product made up of many thin laminae it is possible to eliminate the effect of local defects found in solid wood and to reduce the rate of change of moisture content with resulting dimension changes. Such a material has proven acceptable for use in aircraft, and is finding further applications in other industries.

Dr. Kraemer reports that the most satisfactory laminated wood, either compressed or uncompressed, is made from beech veneers, both with respect to uniformity of product and gluing, primarily because of the uniform structure of this wood. The veneers are selected to exclude all knot holes and large defects, but pin knots and ordinary grain deviations are accepted. It is desired that the veneers be kept at a uniform moisture content of 7 to 10 per cent. before pressing, and they are maintained at this condition through the use of climatising chambers, in which the veneers are placed after removal from the veneer driers. When the panels are pressed it was found that high pressures and long heating times resulted in too large a moisture loss. Therefore, it has been found desirable to form the panels within a mould or to arrange to apply pressure to the sides of the panel as it is being bonded.

Uncompressed laminated wood is normally produced from beech veneers ranging in thickness from 0.1 to 1 mm., bounded together preferably with Tego film glue at 130 deg. to 140 deg. C, and 15 to 20 kg/cm^2 pressure. Liquid resins are of no advantage in the production of laminated wood, since they

contribute too much moisture to the assembly, thus resulting in a less dimensionally stable material with poorer quality glue joints. Therefore, Kaurit glue has been used only with assemblies of thicker veneers, although a new Kaurit film glue has been produced which, from preliminary tests, appears as satisfactory as Tego film glue. The laminated wood panels may be pressed in any size, dependent on the size of press available, but thick panels are difficult to heat uniformly throughout, and it has been the practice to produce thin panels which are subsequently re-glued with cold-setting Kaurit glue. A more satisfactory procedure for forming thick panels is to bond the thin panels together with the aid of Tegowiro film glue, by which method waterproof and boil-proof glue joints can be secured in two minutes' pressing time.

The longest panels which can be produced at the present time are 10 metres in length. These can be glued up in one operation on an hydraulic press which permits production of panels in any length up to 10 metres and up to half a metre in width. The present practice is to make up laminated wood panels to any length, up to 10 metres, by scarfing the individual veneers rather than by scarfing and joining finished panels. These scarfs are normally cut as the veneer is peeled from the log to a slope of about 1 in 20. As the veneers are laid up to form the various laminae of the panel, a strip of Tego film glue is placed within each joint and the joints are staggered within the length of the panel. Only the veneers in the outer one or two laminae are fastened to maintain the position of the scarfs, with the result that some slipping occurs in the interior laminae. This means that the interior scarf joints are not exact, but because of the flat slope of scarf this is not believed to be detrimental.

Compressed Panels

Compressed laminated wood panels are produced in much the same manner as those which are uncompressed except for the higher temperatures and pressures used. Normally the temperature is about 150 deg. C. and the pressure is 200 kg/cm^2. The veneers may be slightly thicker, up to 2 mm. thick, but Tego film is generally used as the adhesive. Contrasted with uncompressed panels, which are usually produced with parallel grain direction of all laminae, the compressed wood panels may have various angles prescribed for the direction of grain in adjacent laminae. In blanks for wood propellers, for example, the veneers are customarily laid up to provide an angle of 20 to 40 degrees between the grain direction of adjacent laminae, with the grain direction of individual laminae at 10 to 20 degrees with the length of the panel. This provides a panel with high strength properties parallel to the panel length, but increases the resistance to splitting.

It has been found from tests that the strength properties of laminated wood increases as the thickness of the laminae decreases, although the density of the material is increased at the same time. The compressive, tensile and bending strength increase from 600 kg./cm., 1,400 kg./cm.^{2} and 1,300 kg./cm.^{2} respectively at a specific gravity of 0.65, normal wood, to 1,315 kg./cm.^{2}, 1,735 kg./cm.^{2} and 1,840 kg./cm.^{2} when 100 laminae per centimetre of finished thickness are used, which results in a material of specific gravity of 1.10. These strengths are further increased in compressed wood, of a specific gravity of 1.42 to 1,460 kg./cm.^{2}, 1,935 kg./cm.^{2}, and 1,920 kg./cm.^{2} respectively. If specific strengths are compared (strength of specific gravity) to the thickness of individual laminae, it is found that the most satisfactory material is one which has 15 to 40 laminae per centimetre of finished thickness. When high strength is required irrespective of weight, the compressed material is preferred and used in aircraft, gears, forming dies and bearings.

The toughness of laminated wood tends to decrease as the thickness of individual laminae is decreased, and the notch sensitivity increases markedly with this decrease due to the increased resin content of the material.

The resistance of laminated wood to the action of oil or gasoline increases as the laminae thickness is decreased. Although tensile strength seems to be unaffected, the compressive strength and bending strength of laminated wood, having 15 laminae per centimetre of thickness, decrease 16 and 45 per cent. respectively after 16 days' exposure.

Shrinkage and expansion of laminated wood also decrease with a decrease in thickness of laminae, and when very thin veneers are used very little dimension change is noted.

—*The Timber Trades Journal*, December 7, 1946.

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INDIAN FORESTER

AUGUST, 1947

WATER DIVINING IN ANCIENT INDIA

By Dr. S. Krishna, C.I.E.

(*Biochemist, Forest Research Institute, Dehra Dun*)

In Varahamihira's *Brihatsamhita*—an ancient Hindu book of direction for the application of knowledge of astronomy and astrology—a section is devoted to *Vrikshāyurveda* (knowledge of tree life) and *Gulma-Vrikshāyurveda* (*gulma*=shrubs and herbs and therefore the entire word means the knowledge of plant kingdom).

The Chapter 53, Vol. II, pp. 706-42 consists of 115 verses, amongst which occur the following*:—

"....Just as there are veins and arteries in the human system (carrying blood) up and down, so there are passages (शिराः) within the bowels of the earth at different depths carrying water." 1.

"If one finds a *Vetasa* plant (*Calamus rotung—sic.*) in a waterless tract, one is sure to find water by digging the ground at a distance of 3 cubits to the west of it half a *purusha*† below the earth." 6.

"If you find a *Jambu* (Blackberry) tree in such a land dig a hole 2 *purushas* deep, 3 cubits to the north of it, and you will find water running in a vein eastward." 8.

"If there be ant-hills close by to the east of the said *Jambu* tree you will surely find sweet water in a pit dug 2 *purushas* deep, 3 cubits to the south of it." 9.

"If a *Udumbara* (*Ficus glomerata*) tree is seen you are sure to find water flowing in a vein, in a pit dug 2½ *purushas* deep, 3 cubits to the west of it." 11.

"If an ant-hill is found to the north of an *Arjuna* (*Terminalia arjuna*) tree, water will be found there 3½ *purushas* under the earth, at a distance of 3 cubits to the west of the tree." 12.

"If *Nirgundī* (*Vitex trifolia*) tree is found with an ant-hill, one will find tasteful water in a pit 2 *purushas* deep, 3 cubits towards the south." 14.

"If a *Vadarī* (*Zizyphus jujuba*) and a *Palāsa*-tree (*Butea frondosa*) are found together you will find good water, 3 *purushas* under the earth, 3 cubits towards the west of the former." 17.

"When a *Vilva* (*Aegle marmelos*) and an *Udumbara* (*Ficus glomerata*) tree are found growing together, you will get water 3½ *purushas* under the surface of the earth at a distance of 3 cubits from the trees." 18.

"Where to the north-east of a *Kovidāra* (*Bauhinia acuminata*) tree is found a white ant-hill with *Darva* (grass) over it, water will be found between them 5½ *purushas* under the ground." 27.

"If a frog is detected living beneath a tree one will surely get water 4½ *purushas* under the ground towards the north of that tree." 31.

"If an ant-hill inhabited by a serpent is found to the north of a *Madhuka* (*Bassia latifolia*) tree, you will get water at a distance of 5 cubits from the tree, 7½ *purushas* under the ground." 35.

"If you find a Palmyra tree or a Cocoanut tree with ant-hills, you will have a vein of good water flowing at a distance of 6 cubits to the west of either of the above trees 4 *purushas* under the ground." 40.

"There is water by the trees that are sappy, have long branches, or very dwarfish, or very spreading. And there will be no water near the trees that are sickly, have unhealthy leaves, and vapid." 49.

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*Translated by Mr. G. P. Majumdar, in Section IX, pp. 135—138, of his book *Vanaspati* (Plants andPl ant-life as in Indian Treatises and Traditions), Griffith Memorial Prize Essay for 1925, published by the University of Calcutta, 1927.

†*Purusha.*—One *purusha* is equal to 120 *angulas*—about 7 ft.

"Water will be found $4\frac{1}{2}$ *purushas* below the ground at a distance of three cubits to the north of the following trees surrounded by ant-hills: **Tilaka, Amrātaka, Varunaka, Bhallātaka, Vilva, Tinduka, Ankola, Pindara, Sirīsa, Arjuna, Parushaka, Vanjula* and *Atibala*."

50 & 51.

"If a thorny tree (*e g. Khadira*) is found in the midst of thornless ones (like *Palasa*), or a thornless tree is found in the midst of thorny ones, water will be found 3 *purushas* under the ground at a distance of 3 cubits to the west of such a tree."

53.

"If a *Kantakarika* (*Solanum* sp.) plant is found without thorns and with white flowers, water will surely be found under it at a depth of $3\frac{1}{2}$ *purushas*."

57.

"The region where trees, shrubs and creepers are graceful possessing leaves that are untorn (entire) there are veins of water 3 *purushas* below the ground. Or where there are *Sthalapadma, Gokshura, Usira, Kula* with *Gundra, Kasa, Kusa, Nalik* or *Nala* (all grasses); or where there are *Kharjjura, Jambu, Arjuna, Vetasa*, or trees, shrubs or herbs with milky juice, or *Chhatra, Hastikarna, Nagakesara, Padma, Nipa, Naktamala* with *Sindhubara* or *Vibhitaka, Madayantika*, there will be found water 3 *purushas* below, even if it be on the mountain upon another mountain, *i.e.*, on a very high ground."

100, 101 & 102.

"Where there are *Saka, Aswakarna, Arjuna, Vilvasarjja, Sriparni, Arishta, Dhaba, Simsapa* with leaves torn (*i.e.*, unhealthy), and where the trees, shrubs and creepers look ungraceful, water is to be inferred to be off from that locality.

105.

*The following are the latin equivalents of the Sanskrit names given in verses 50 to 105:—

amrataka	(*Spondias pinnata;* syn. *S. mangifera*)
ankola	(*Alangium lamarckii*)
arishta	(*Azadirachta indica*)
arjuna	(*Terminalia arjuna*)
aswakarna	(*Shorea robusta*)
atibala	(*Sida rhombifolia*)
bhallataka	(*Semecarpus anacardium*)
gokshura	(*Tribulus terrestris*)
gundra	(*Cyperus rotundus*)
hastikarna	(*Colocasia macrorhiza*)
jambu	(*Eugenia cumini;* syn. *E. jambolana*)
kantakarika	(*Solanum* sp.)
Kasa	(*Saccharum spontanum*)
khadira	(*Acacia catechu*)
kharjjura	(*Phoenix sylvestris*)
kusa	(*Eragrostis cynosuroides*)
nagakesara	(*Mesua ferrea*)
naktamala	(*Pongamia pinnata;* syn. *P. glabra*)
nalik or nala	(*Phragmites roxburghii*)
nipa	(*Anthocephalus cadamba*)
padma	(*Nelumbium speciosum*)
palasa	(*Butea monosperma;* syn. *B. frondosa*)
pindara	(*Trewia nudiflora*)
saka	(*Tectona grandis*)
simsapa	(*Dalbergia sissoo*)
sindhubara	(*Vitex negundo*)
sirisa	(*Albizzia* sp.)
sriparini	(*Gmelina arborea*)
sthalapadma	(*Hibiscus mutabilis*)
tilaka	(*Symplocos racemosa*)
tinduka	(*Diospyros embryopteris*)
usira	(*Vetiveria zizanioides*)
vanjula	(*Saraca indica*)
vetasa	(*Calamus rotang*)
vibhitaka	(*Terminalia belirica*)
vilva	(*Aegle marmelos*)

MANURING*

The Evil Effects of Utilization of Dry Leaves from Forests —Forest Leaf Litter—Humus

BY RAO BAHADUR M. S. RAGHAVAN

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Due to the present world shortage of foods, our minds constantly explore possibilities of increasing production of food stuffs in our fields and gardens. The growing of more food can be achieved either by bringing more land under cultivation, or by increasing the fertility or productivity of the land already under cultivation. Increase of fertility of land suggests the use of fertilizer; and in this connection it is sometimes thought that dry leaves and leaf litter obtained from forest trees may be used as manures.

The original form of the word manure was "man ouvre" meaning tilling by hand—the manual cultivation of the soil. It is very well known to practical agriculturists, that the more the surface soil is dug up and turned, the greater is its aeration, granulation and mellowing, and greater successes in growing field crops are assured. Thorough tilling is in itself one of the best means of making plant foods in the soil available for the plants, and of thus increasing the productivity of the soil. The addition of lime, clay, dung, and various fertilizers either release or supplement the essential constituents already present in the soil.

The fertility of any soil in supporting any vegetation depends on its physical characteristics, chemical constituents, and on the activity of some living organisms in the soil called germs or bacteria. As there is life in the soil, every agriculturist and forester knows that the soil must receive all the care and attention that any life requires. Once the life in the soil is taken by unscientific management, we cannot bring it back to life. Science has not yet advanced to that extent.

Due to their physical properties, soils provide physical support for plants and absorb and retain sufficient moisture for them. In addition they serve to carry the chemicals necessary for plant life, and provide a suitable medium for the working of live soil organisms.

While digging and soil working affect favourably the physical characteristics of the soil, and considerate treatment helps the beneficial bacteria, the chemical constituents require addition, if the soil gets depleted of these. Such additions are made by the introduction of suitable organic or inorganic substances as manures.

With very few exceptions, nearly all soils benefit by the addition of organic matter, such as the addition of cowdung, or the growing and ploughing in of green crops. Such an addition renders the soil light, easier to work, more porous, more capable of retaining moisture, and so better able to withstand drought. Such a soil also retains satisfactorily ammonia and potash, and liberates them as wanted by the plant. Decomposing organic matter liberates carbon dioxide, which in the presence of moisture, becomes carbonic acid capable of corroding phosphates, and making them available for plants.

Almost every soil is sufficiently supplied with small quantities of sulphates, magnesia and iron, required for plants. Though in some places, as in the Nilgiris, there may be an insufficiency of lime, in most cases lime is also available. Our attention has therefore to be concentrated on supplying plants with sufficient quantities of potash, nitrates, and phosphates. The requirements of plants with regard to these differ. Their importance also varies. They should be in a form in which the roots can feed on them when required. Given these three in adequate quantities, plants flourish if climatic conditions are suitable. Deficiency or absence of one of these cannot be compensated for by an excess of either or both of the other two. These three, in adequate quantities, form the "Golden Tripod" of fertility.

Potash increases quality of our crops such as the sweetness of canes, or aroma, etc. Generally all garden and agricultural land is said to have a sufficiency of potash which however may require the addition of lime to make it assimilable by plants.

Nitrates favour vegetative activity. They produce an effect that pleases the eye with the beautiful large dark green leaves, and rank luscious growth of the plants. The nitrogen contained in most organic refuse undergoes constant change, till ammonia is produced. Though plants can with difficulty take up ammonia,

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they prefer nitrogen as nitrates. The building up of nitrogen into nitrates in nature's laboratory is done by certain minute living organisms called bacteria. Ordinary cultivated land has sufficient of these bacteria, and a proper supply of oxygen occurred by soil working and tilling are sufficient operations to keep these bacteria healthily active in the fixation of atmospheric nitrogen. Good drainage, promoting aeration is an essential condition. Drought and cold retard bacterial action, and kill them. In a well worked moist warm soil, the fixation of nitrogen is satisfactory. As soil working prevents desiccation, and helps moisture retention, soil working helps the nitrifying bacteria.

Nitrates however do not favour the production of fruit or grain. Every agriculturist knows that when his field crops bear a profusion of luscious green leaves, the expectation of grain yield is poor. So powerful is the effect of nitrates in encouraging leaf production, that all the energy of a plant may be concentrated on stem and leaf, to the detriment of grain.

With phosphates however the result is different. Every agriculturist knows when he is to expect a bumper crop of grain, though the apparent sparsity of green leaves may be distressing to the untrained eye. It is by supplying a sufficiency of phosphates, and not of nitrates, that we shall grow plenty to eat and sell, of corn, of grain, of fruit.

Phosphates promote fruitfulness and early ripening. From the use of the term fruitfulness it may sometimes be thought that phosphates are more required in a fruit garden, than in agricultural land intended for the production of cereals. As the grains we eat are also the fruits of plants, provision of sufficient phosphates in an assimilable form is required for our fields. Of phosphates we often have calcium phosphate, iron phosphate, or aluminium phosphate in the soil, but as they are in an insoluble condition, they are not immediately available. Methods, such as the addition of lime to certain soils, for rendering the soil phosphates soluble, need to be adopted. It is perhaps much easier and quicker to purchase proprietary phosphatic manures, which with varying acidity, are soluble to varying degrees, so that the availability of the phospates from such manures can be controlled at will.

The following paragraphs indicate which of the above constituents may be expected in forest leaf and litter, and to what extent. We also get an indication as to how far the use of such litter will help us to grow more food.

In forests the greater part of all organic matter produced is retained in the wood, while all the mineral matter taken by the trees from the soil is returned to the soil in the annual leaf fall. An estimate by Prof. Nemac of Prague shows the following average amounts in lbs. per acre of nitrogen, phosphate, potash, and lime taken by beech, spruce and pine forests. As such analyses are not available for Indian forests, these figures are presented in Table I to give an idea of the comparative amounts of the different ingredients. Prof. Nemac has calculated in Kilogrammes per hectare, and the writer of this note has converted them into lbs. per acre rounded off to the nearest unit to facilitate understanding.

TABLE I

Constituent	lbs. per acre, in forests of		
	Beech	Spruce	Pine
Nitrogen	30	45	36
Phosphate radical	10	6	3
Potash	9	4	4
Lime	47	54	17

According to Ebermeyer, an average forest crop, including wood and leaves, requires annually only about 54 per cent of the mineral substances necessary for an average field crop, on an equal area. Of this, forty-six per cent is stored in the leaves, and eight per cent in the wood. So, a forest crop takes from the soil annually only about one-twelfth of what a field crop would take, if the wood alone is removed but not the leaves.

If from an acre we remove forty-six per cent of the nutrition annually required for producing a field crop on it, it is easy to understand that the productivity of the forest must disappear completely in about twice the time that it will take for a field to become unproductive, if we remove from it every year a field crop without adequate manuring. As our forests have always been left or created in areas that were either originally unsuited to ordinary cultivation, or after a short period of cultivation, have been abandoned due to unfruitfulness, or unhealthiness, and as it is not feasible to restore by soil working or manuring any ingredient that has been removed from the area, it can be realised that if a forest area annually loses forty-six per cent of the nutrition of corresponding field crop, the impoverishment of the soil in the forest area,

will make itself felt in a short time. Such impoverishment can be determined by chemical analysis.

Nemac analysed a number of comparable oils from untouched mature spruce and pine forests, and from similar forests where the leaf litter was annually removed. The average losses of nutrient substances from the cleared plots, expressed as the percentages of the amounts existing in the untouched plots are given in table II below.

TABLE II

Forests	Soil depth	Losses—percentage (in litter cleared forests) total					
				Phosphate		Potash	
	Inches	Organic matter	Nitrogen	Total	Citric soluble	Total	Citric soluble
Spruce ..	0–0.8	61	60	64	77	45	53
	2–4	24	31	40	20	10	13
	4–10	28	28	1	12	3	0
Pine ..	0–0.8	72	88	67	92	0	73
	2–4	57	61	16	27	0	28
	4–10	10	2	0	14	0	2

The huge losses of nitrogen and phosphate from the surface layers, and the much smaller losses of potash are noticeable. Again if from table I above we remember that the nitrogen content of leaf litter is about six times the phosphorus content, we realise that when forest litter is used for manuring agricultural land we are giving them a lot of nitrogen which will increase vegetative activity, and less of phosphates needed for production of grain; and little or no potash needed for sweetness, flavour, colour, and other desirable qualities.

We have indicated above that an impoverishment of the forest soil may be expected from litter removal. It has been established by careful analysis in Europe that when the ash of pine needles is analysed, a progressive deterioration in the manurial value of leaf litter is noticed. When the ash of pine needles from litter-cleared forests was compared with the ash of similar needles from the forests where the litter was not cleared, the comparative results given in table III below were obtained.

TABLE III

Constituent	Percentage in forests where	
	Litter is removed	Litter is not removed
P_2O_5 ..	6.9	10.4
$Si\ O_2$ ..	7.8	9.8
K_2O ..	44.7	21.2
Na_2O ..	3.3	13.0
CaO ..	9.3	10.2
MgO ..	3.7	6.4
SO_3 ..	5.5	7.5

The above data show, that, except for an unexplained increase in potash, all the other ingredients have fallen considerably in pine needles from forests where the litter was removed. The nitrogen content of the needles (not analysed in the ash) had fallen also by about 12 per cent. This shows that repeated removal of leaf litter from forests, results in the degradation of the litter itself, so that it is no longer as nutritious as it should be for fertilizing crops.

Bleual has shown that annual removal of leaf litter during periods of 23 to 30 years caused a falling off of increment in old beech woods on inferior soil of 32, 39, 42 and even 58 per cent, while on good besalt soil the loss was only 8 per cent. Under similar conditions, the loss of increment in scots pine wood of good quality was 7.5, 9.3 and 10.9 per cent. Removal of litter in broadleaved forests appear to cause greater loss of increment than removal from coniferous forests. Except a few exotics on the tops of our hill stations, our Madras forests are broadleaved.

Removal of leaf litter every three years in the Spessart from beech woods caused a loss of increment of 13 per cent, while removal of it every six years caused a loss of 10 per cent. These observations further showed that the loss of increment increased steadily from period to period. The shorter the period between consecutive removals of the litter, the greater the injury to the tree crops.

The change in the composition of the litter exhibited in table III above, really reflects a corresponding change in the composition of the leaves. Such a change in the composition of

the leaves cannot but uspset the balance of physiological processes in a tree and damage the growth and quality of the trees. The rapid depletion of the nitrogen and phosphate contents of the litter where litter removal is allowed indicates that for a short-lived benefit of an acre of agricultural land we shall permanently damage a larger area of forests, from which we can never get any wood, or litter of the value we have now got. The productive capacity of the forest cannot be restored, as manuring of forests even under normal conditions is unthinkably costly. Again, though forest litter is sometimes richer in nitrogenous material than some field refuse such as straw, it is generally much poorer in potash and phosphates. But for growing food crops the need for phosphates is emphasized more than that of nitrogen.

The removal of litter, will also indirectly affect the stocking in the forests. Several forest trees, such as *Evodia roxburghiana*, which is now assuming considerable importance in the softwood trade, are surface rooters. Even *Casuarina*, in sandy plantations, tends to be a surface rooter if the subsoil tends to be hard. In the drier regions, where the subsoil is rocky or there is a pan formation, many of the trees live by superficial rooting. In such places, the existence of the leaf mould, prevents desiccation of the soil from which the root system of these plants is drawing up nourishing water. If the leaves and litter which protect these superficial roots are removed, death of species which are superficial rooters will follow. The composition of the forest will change, and the stocking deteriorate. What is already open forest, will become still more open. Our timber and fuel supplies will become less.

Removal of litter as shown above exposes the soil. Normally the fallen leaves, litter and vegetable mould on the forest floor cushion the hardening effect of the hooves of animals, and of the rain which would otherwise set directly on the soil. If the litter is removed, and the soil exposed, there i a tendency for the soil to be eroded, which will be dealt with in a later paragraph, and for such soil as is not eroded to be compacted hard. The radical of germinating seedlings cannot penetrate such compacted soil, and large numbers of seedlings die in such areas, instead of establishing themselves, as they would do if they had a soft porous moist soil as is provided by leaf litter and humus. The absence of natural regeneration, also tends in the depletion of stocks in our forests.

As indicated in the previous paragraph, erosion is a danger that has to be contended against. It is generally known that rain water that falls on the ground is disposed of in three ways. Part of it evaporates and is lost. In the process of evaporation there may be a slight cooling effect, though the water is lost irretrievably. But this loss does no immediate, visible physical damage to the soil. Part percolates into the soil, reaches a smaller or greater depth according to the nature and condition of the soil, subsoil, and rocky substratum, moves underground without damage to the soil, gets filtered, dissolves minerals, and reappears in springs and wells for our needs. A third part runs off the surface, and if the ground is exposed, erodes the soil, and flows into the nearest watercourse.

Most of the rain water falling on a bare slope, carrying with it the soil that it has torn off from the surface, rushes down into the nearest watercourse in a comparatively short time, causing in it a rapid rise of level. Only a comparatively small fraction sinks underground, so as to be available for feeding springs and wells. The surface soil carried by the flowing water into the streams and rivers, is deposited with a lowering of velocity when the slope becomes gentler, the normal course of the stream on river is blocked, the floods diverted, new channels cut, and valuable stretches of cultivated land, villages, houses, hayricks, cattle and men, women and children, carried away. Though sometimes fertile deposits on lands at the foothills please the people who own such lands, more often it is a deposit of infertile mineral soil washed down from the hills on fertile cultivated lands, resulting in decreased productivity, compelling the farmers to leave home and village, and settle elsewhere. Such destruction is sometimes spectacular and commands immediate attention; and control methods including afforestation and forest protection are prescribed.

More often the damage is insidious, and is not realised, till it is irreparable. The abandoned villages at the foot of the hills in the drier districts, the burst dams of reservoirs built by our ancient rulers for the benefit of village communities in the vicinity of our ancient forests, bear testimony but too often to the destruction of erosive rivers and streams.

If the rain falls on a forest area, where the leaf litter has been left on the grounds, about one-fourth of the rain is intercepted by the crowns of the trees, and the other three-fourths falls upon a layer of leaf litter or humus. This humus has been found to have the capacity of absorbing as much as about five inches of rainfall just as a sponge can do, and to retain it for a time. The evaporation from this humus-retained moisture is only about one-fifth of the evaporation of moisture from open and unforested soil. It is less than half that from forest soil where the leaf mould has been removed. The leaf mould therefore can protect up to about five inches of rainfall against surface drainage, and protect about four inches of it against evaporation.

Part of the water thus absorbed by the humus penetrates into the ground and after passing through the soil and subsoil, and interstices in the underlying rock, reappears in streams and wells. If the leaf mould had been removed only a very small fraction would have had a chance of going underground, as most of it would have flowed away on the surface ; and thus got irretrievably lost after doing considerable damage, as shown above.

In the previous paragraph, we have said that part of the water, absorbed by the humus or leaf litter goes underground. The other part is slowly released by the humus over a long period, and it finds its way as clear limpid water in small but continuous quantities into the nearest streams and rivers, which can be efficiently impounded, diverted, canalised, and utilized for agriculture. If the rain is in excess of the five inches mentioned above, the leaf litter, and humus, allow superficial drainage, but retard the velocity of the water, so that it escapes without damage ; and even this water, can be impounded and utilized as it flows comparatively slowly.

In the absence of a cushion of leaf litter or humus in the forest the rapid superficial flow of water is such as not to be available for the community in the vicinity. Practically all the water being lost superficially thus, the percolation of the water is negligible, so that not only people in the vicinity, but people farther afield who depend on well water, face drought, poverty, starvation and death.

Though forest litter is sometimes richer in nitrogenous material than straw, it is often much poorer in potash and phosphoric acid. For food crops the grain of which we eat, it is probably more of potash and phosphorus than nitrogen that we want. The utilization of forest leaves, or leaf litter, or humus (all of which represent different stages of the same material) will merely result in the leafy growth of agricultural crops, without the production of the much wanted grain. The damage however to the forests physically, chemically, and biologically will be irretrievable. Though we have our forests and rivers, and mountains we love our country more. Most of all we love our countrymen and our countrywomen. The temporary benefit to a small community in the immediate vicinity of our forests resulting from the utilization for fields of dead forest leaves, or leaf litter, will be more than offset by the permanent damage to the agricultural interests of a larger community, perhaps twenty miles off, depending on well water for their life and living. The very basis of civilization in India, may be its life itself is threatened, if communities near our forests are allowed to remove leaf litter. Once erosion has started, immediate and economic redress is not possible. The *restoration to fertility of* damaged areas can never be achieved without costly construction of dams, dykes, *walls, and* similar gigantic engineering structures, and the use of costly *artificial fertilizers for growing* forests again. If removal of leaf litter from forests is assured, *sooner or later,* we shall have no forests from which to get out fuel to cook our food, nor the timber for our agricultural implements and houses or huts. While mistakes made in *agriculture* can generally be rectified after the lapse of one or two seasons, a mistake in forestry exhibits results only slowly, and then the damage would have gone too far for economic repair.

It is realized that the removal of litter is permitted under special conditions in some European countries. But it is allowed from places where its presence is abundant, where its depth is so deep and the rainfall so heavy that the retention of litter may result in acidity of the soil ; where the soils are mineralogically rich ; and where areas are NOT devoted to the production of TREES. Its bad effects are said to be nowhere greater than on shallow soils with a subsoil of gravel, etc. Even for European ideal conditions, Sir William Schlich, one of the greatest authorities in forestry writes that there can be no real necessity for the concession of removal of forest litter, where the farmer adopts improved agricultural methods. He adds that the exceptional hurtfulness of such removal to the productiveness of a forest, may lead to the complete ruin of a forest, and recommends that it is most essential that even where such rights exist, such rights should be extinguished by purchase or otherwise. In India our forests nowhere contain such a superabundance of litter, that removal will be justified. Sir William Schlich's recommendation that it is probably better to improve farming methods by learning the best and most recent methods of farming than to remove forest litter, therefore, applies even more forcibly to Indian conditions.

If loss of water by evaporation can be reduced ; if loss of valuable land by erosion can be checked ; if surface water can be filtered, its velocity reduced, and the clear water led slowly through well regulated channels into the great tanks that our ancient and modern rulers have built for us, and if more of the rain water is allowed to descend deep down to reappear far away in sparkling springs, bubbling brooks, and in deep wells, we shall have helped our countrymen in one of the best ways possible. One of the best ways of achieving these objects is leaving untouched the fallen leaves in the forests, to form a porous spongy mass of leaf litter or humus, which can absorb, retain, filter, and release in regulated quantities

into superficial and underground drainage, the water from the sparse rainfall of our drier regions. More forests, and more leaf litter is what our country wants.

A careful examination of the problem indicates that the removal of leaf and litter from the forest is definitely harmful to our forests, and will soon result in the reduction of all available forest material needed for our very life; that such removal will result in the erosion of forest soil, and of the deposition of the lower layers of mineral soil on cultivable fields at the foot of the hills, and in the neighbourhood, rendering them sterile, and reducing areas under cultivation; that the exposure of forest soil will increase surface drainage, resulting in disastrous floods; that the reduction of subsoil drainage will cause the lowering of the water level in wells and springs and drought in localities farther from the forest fed by such springs and wells; that the use of leaf litter from the forest may cause a pleasing increase of vegetative growth of field crops, but no appreciable increase in the fruit and grain we need for our food; and therefore it is necessary for the benefit of the country to leave the leaf litter in the forests, and to adopt improved methods of agriculture such as tillage, growing and ploughing in of green manuring crops, growing near villages in areas specially set apart rapidly growing trees such as *Poinciana alata* for green leaf manure, the use of phosphatic manures, etc., subjects which our expert agricultural department and forest department can advise on and demonstrate.

Note—This paper is included under this conference subject head and not under item 10—Soil problems—as litter removal is much more serious in its effects in the dry areas than in the moister parts. In attempting the afforestation of a dry area which contains any scrub at all the removal of litter cannot possibly be allowed. *Central Silviculturist.*

GROWING SPACE AND HEIGHT CORRELATION

By K. P. Sagreiya, I.F.S.

(Divisional Forest Officer, Jubbulpore).

If thinning of teak crops on the basis of *number of stems per acre/crop diameter* correlation is considered objectionable or impracticable, they may be thinned on the more natural *growing space/height* correlation as suggested by Wilson in his article entitled '*Numerical Expression of Stocking in Terms of Height*' published in the American *Journal of Forestry* for October 1946.

Wilson argues that although the *N. per acre/crop diameter* correlation is a good guide when carrying out the first thinning, subsequent thinnings on this basis may prove unsatisfactory because "diameter is the result rather than the cause of spacing". On the other hand, height, within reasonable limits of stocking is negligibly affected by spacing, and has the virtue of combining the factors of age and site quality in one measurement.

Admittedly, when crops are thinned on the N/D basis the stems with larger diameter are given greater growing space. This may be objected to from the strict silvicultural point of view, but from the value-yield point of view, if anything this is an advantage so far as teak is concerned because larger sizes are worth more per cubic foot as also per unit of growing space occupied. Therefore, this silvicultral objection need not deter us from carrying out thinnings in divisional practice on N/D basis whenever practicable.

As, however, the estimate of the height of a tree or a crop is equally easy—after some measurements, if necessary, either by felling a few trees or by using any good hypsometer,—thinning on *height/spacing* basis deserves consideration.

Wilson cites Tkatchenko's formula—which the latter credits to Keller—for thinning stands of spruce. According to this formula the average spacing is one-sixth of the crop height. Assuming Keller's concept to be basically sound, Wilson suggests the following formula for uniformly stocked evenaged stands—

$$n = \frac{43560}{(hf)^2}$$

Where n is the number of stems per acre, h is the crop height and f is a fraction of height appropriate for the species. If f is a constant and h is plotted against n on a double logarithmic paper, the graph will be a straight line with a slope defined by 2 log $h = -$ log n, *i.e.* the ratio n/h^2 is independent of age or site quality.

In support of this he cites the following data from yield tables.

TABLE I

Value of *Spacing/Crop height*

Age.	For site quality Good	Medium	Poor
		Jack pine	
30	18	20	22
40	18	19	21
50	18	19	21
60	17	19	21
70	18	19	21
80	18	20	22
		Aspen	
20	12	12	12
30	14	14	41
40	15	15	15
50	16	16	16
60	17	17	17
70	17	18	18
80	18	19	20
		Red pine	
40	20	21	20
60	18	18	19
40	17	17	19
100	17	17	19
160	18	18	20

TABLE II

Value of *Spacing/Average height*

Age	For site quality Good	Medium	Poor	Good	Medium	Poor
	All trees			Dominants		
			Black spruce			
40 ..	13	12	13	18	18	20
60 ..	12	12	12	17	17	18
180 ..	12	11	12	16	16	17
100 ..	12	11	12	15	16	17
160 ..	11	11	11	15	15	16
			Red Oak			
20 ..	16	16	16	22	22	23
40 ..	18	17	17	22	22	23
60 ..	19	19	19	23	23	23
80 ..	20	20	20	23	24	24
100 ..	21	21	21	24	24	25
160 ..	22	23	22	25	26	26

From these data he derives the following conclusions :—

(1) The factor f (spacing / height) decreases with tolerance to side shade, *i.e.* Aspen is more tolerant than Pine. The discrepancy between the Red and Jack pines is explained by the fact that the latter while definitely more intolerant, can endure extreme crowding from the side.

(2) The factor f is unaffected by site quality.

(3) The factor f increases when the suppressed trees are excluded.

(4) The factor *f* increases with age in the case of species that have a natural tendency to thin out with age (aspen and red oak) and decreases with age in the case of species that naturally tend to become more crowded as they get older (black spruce). These trends might well be a reflection of the characteristic differences in the crowns of the species, and therefore species that have a tendency to become more crowded, especially when originating in dense stands, should benefit most from thinnings.

Working with the Indian teak and *sal* yield tables the following figures are obtained.

TABLE III

Value of 100 d/H

Teak

Age	All India site quality		
	III	IV	V
10	27.7	29.6	30.0
15 ..	27.7	28.6	28.6
20 ..	28.2	29.0	29.5
25 ..	29.2	30.0	30.6
30 ..	30.0	31.2	31.8
35 ..	30.6	31.7	33.2
40 ..	30.6	32.1	33.4
45 ..	31.1	33.2	33.7
50 ..	31.4	33.4	34.1
55 ..	31.4	33.6	34.2
60 ..	31.8	34.5	33.9
65 ..	32.4	35.0	33.8
70 ..	33.8	35.5	34.2
75 ..	34.2	36.5	34.4
80 ..	35.0	37.4	35.5

Sal

Age	All India site quality		
	I	II	III
10 ..	36.2	40.0	50.0
20 ..	26.6	29.8	35.0
30 ..	24.2	27.4	32.1
40 ..	22.6	25.8	30.6
50 ..	22.4	25.0	29.5
60 ..	22.1	24.7	29.0
70 ..	22.3	25.0	29.8
80 ..	22.7	25.6	31.0
90 ..	23.5	26.4	32.0
100 ..	24.0	27.3	33.3
110 ..	24.8	27.7	34.7
120 ..	25.0	29.2	35.6
130 ..	26.0	29.8	37.0
140 ..	26.6	30.5	37.5
150 ..	27.7	31.6	38.2

On Wilson's argument, the following deductions are justifiable from these data:—

(1) The factor *f* is comparatively lower for the somewhat shade tolerant *sal* than for the extreme light demander teak.

(2) The factor *f* is practically unaffected by site quality variation.

(3) For teak the factor *f* slowly but steadily increases with age. In other words teak has a tendency to spread out with age. On the other hand for *sal* it has the reverse tendency up to 60 years of age, *i.e.*, *sal* tends to get crowded in early life or is shade tolerant, and thereafter it slowly but steadily tends to spread out or becomes a light demander.

Be that, as it may, so far as teak is concerned one important fact emerges from these tables *viz.* that the *growing space after thinning is* more or less *equal to one-third top height*. This fact can therefore with advantage be made use of when carrying out crown thinnings in irregular teak crops with a large proportion of non-teak species, as is the case with the Central Provinces forests. This rough and ready check should at any rate prevent unduly heavy thinnings which are often carried out.

ERADICATION OF WHITE ANT INFESTATIONS*

BY S. V. GULVADI

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SUMMARY.—This paper describes the successful eradication (1) of white ant infestations inside a building and (2) of white ant colonies in mounds in the open, with insecticides, named Gammexane D 025 (a white powder) and Gammexane LG 140 (a liquid), obtainable from Messrs. Imperial Chemical Industries (India) Ltd, 18, Strand Road, Calcutta.

Introduction

White ants are a problem for every house and even a tent dweller in India as they not merely invade habitations and damage woodwork, but can destroy valuable clothing, carpets, books and the like. Forest range officers who have the care and maintenance of forest rest houses and other buildings as part of their normal routine duties, sometimes experience great difficulty in eradicating these infestations. The writer of this article had to deal with a troublesome infestation in one of the two bedrooms of the forest rest house at Yellapur. This bungalow was built some 40 or 50 years ago. In the usual course of annual repairs the white ant galleries used to be scraped, coal tar applied and the wall even cement plastered, but the galleries reappeared, after a while, year after year.

In December 1945, at the instance of the conservator of forests, the writer addressed the Imperial Chemical Industries (India), Ltd., 18, Strand Road, Calcutta, who sent him for trial an insecticide called Gammexane D 025, which they claimed would destroy white ants coming in contact with it.

Experimental Trials Inside a Building

Gammexane D 025 is a white powder, containing 5 per cent. benzene hexachloride, 13 per cent. of which is in the form of the effective Gama isomer. The instructions of the I.C.I. were to use a non-alkaline diluent (using ten times of an inert diluent like talcum powder, road dust, French chalk or gypsum). The idea was that the white ants coming in direct contact with the dust will not die forthwith because of the dilution, but instead would go back alive to the interior of the nest and die there, with the result that the other white ants (meaning largely those other than the workers and the soldiers) will eat the dead bodies and die in turn, thus bringing about a complete annihilation of the whole colony.

As the first set of instructions did not specify the diluents by name, the writer prepared an emulsion of Gammexane D 025 with ten times its weight of water and used it in the opened up portion of the wall of the rest house, on the white ants that were crawling about, as well as by pouring it into the cavities of the infestation. The powder was also blown into the holes with a glass tube blower, operated by a rubber bulb. Within a short time all the white ants in and around the affected portion were completely destroyed and there never was a reappearance of the tell-tale galleries. The wall was left open for about three months and then rebuilt with bricks. This forest rest house has since been completely free of damage from white ants.

Experimental Trials in the Open

It was, of course, not possible in this case to trace the mound or the source of origin of the invading white ants. On examination of the white ant hills within about 200 feet of the same forest rest house, no connection with the infestation of the rest house was disclosed. Trials on mounds in the open field were, therefore, next thought of.

Further supplies of the insecticide were ordered from the I. C. I. who also sent another brand of the insecticide called Gammexane LG 037 in liquid form, to be used in mixture with kerosene at the rate of 1.6 per cent of the liquid, or, say 9.1 c.c. of the new product to a pint of kerosene.

On the 7th June 1946, Gammexane D 025, full strength, at the rate of 8 oz. per white ant hill of 18 inches to 24 inches diameter and 20 inches to 28 inches in height above ground, was applied in the field to three ant hills, after opening them and exposing the network of runways. When these nests were dug up on the 15th June 1946, there were no white ants inside, nor was there any trace of them or of the queen ant.

Thirteen nests in all were thus destroyed; a single application being enough, except in the case of two nests of 48 to 60 inches diameter for which two applications each were employed. In these two cases, a queen ant (a soft white bag of tissue 3 to 4 inches long and half an inch in diameter) was found in each, at ground level, but in the other eleven mounds no trace of the queen ant could be found.

*Largely recast by the Hon. Ed., *Indian Forester.*

The other brand of the insecticide, Gammexane LG 037 in kerosene, was applied at the rate of 100 c.c. per nest for three successive days, *i.e.*, on the 28th, 29th and 30th June 1946, for nests of about 24 inches in diameter, 9 to 12 inches in height above ground, poured in through holes, after the mounds had been opened up. When the nests were dug up (they went down to about 18 inches) no white ants or their queens were found.

These observations were checked by three control mounds that were opened up similarly and at the same time as the treated mounds, but were not subjected to either Gammexane D 025 or Gammexane LG 037. The holes of these control mounds were sealed up in a day or two of the opening by the white ants which continued to live and prosper.

Indications for Future Work

In all future work the termites met with should be correctly identified. Specimens can be sent to the Forest Entomologist, New Forest, P. O., Dehra Dun, for identification.

A trial on the lines indicated by the I. C. I., with a diluent for Gammexane D 025, is well worth trial, as it will result in reducing the cost of the chemical.

Gammexane LG 037 has now been replaced by Gammexane LG 140, a highly refined, almost odourless and non-irritant oil-based liquid concentrate containing 10 per cent. of Gammexane against 7 per cent. in LG 037.

Acknowledgments

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(1) Mr. J. Walker, Conservator of Forests, Southern Circle, Bombay.

(2) Divisional Forest Officer, Kanara Eastern Division, Bombay.

(3) Messrs. Imperial Chemical Industries (India) Ltd., Calcutta.

NOTICE

A short history of the Assam Forest Service 1850—1945, by H.P. Smith, B.A. (Cantab.), B.A. (Oxon.), C.I.E., I.F.S., and C. Purkayastha, B.A., I.F.S. (Diploma), is available for sale by the Conservator of Forests, Assam, Shillong P.O., at a price of Rs. 2-4-0 per copy in addition to V.P.P charges.

THE FUTURE OF FORESTS IN AHMEDNAGAR DISTRICT

BY B. S. BATHENA

(*Indian Forest College, Dehra Dun*)

Forests contribute to the wealth and well-being of a nation, province or district both directly through the revenue accruing from them and indirectly by maintaining conditions suitable for the production of agricultural and fruit crops from the land. The latter indirect influence is by far the more vital and far reaching in its effects and, although its importance has only recently been appreciated the day is definitely past when forests were raised for revenue alone. Forests provide soil cover which is the first essential for the continued maintenance of the fertility of a soil besides forming 'nature's large reservoires' for storing up rain water and gradually yielding it up to streams, rivulets and rivers; and thus are responsible for creating conditions favourable to the raising of field crops. It is for this reason that it has become necessary to afforest barren areas. Ahmednagar district is mostly barren and subject to heavy erosive action; and consequently in urgent need of protection. It has recently been decided by the Bombay Government to afforest the district as far as possible.

Geographical Situation

Ahmednagar district is bounded on the north by the Godavari river and partly by the Nasik district and partly by the Nizam's dominions; on the west by the Thana and Poona districts, the north west corner arising in the foot-hills of the Western Ghats; on the south by the Poona and Sholapur districts, and on the east totally by the Nizam's dominions. The district lies between longitude 73°-45′ and 75°-40′ East and latitude 18°-35′ and 20° North. A range of hills runs in an almost unbroken chain right across the district from the north-west to the south-east corner. Ahmednagar city stands on a plateau at nearly the middle of this hill range which divides the district into two almost equal parts. The north-east portion descends to the river Godavari and its tributaries of which the Pravara and Mula, and the Dhor are worthy of mention and the south-west portion descends to the river Bhima and Ghod its tributary. Another important river, the Sina has its origin on the Ahmednagar plateau and flows in-between hills in a roughly south-easterly direction. The mean altitude of the district is roughly 2,000 feet above mean sea level, the highest peaks in the north-west being well over 3,000 feet. The district is divided into the following 13 *talukas*:—Ahmednagar, Rahuri, Shrigonda, Parner, Karjat, Pathardi, Jamkhed, Newasa, Shevgaon, Belapur, Sangamner, Kopergaon and Akola.

Climate and Rainfall

The mean annual temperature is in the neighbourhood of 78°F. The climate is rather of an extreme nature the maximum in summer raising to over 110°F. in the shade and the minimum in in winter falling as low as 40°F. at night. The diurnal range is about 30° F. Ahmednagar district receives an average rainfall (annual) of 20 inches in an average of 30-35 rainy days. The rainfall is distributed over a short period at the end of the rainy season and this year (1946) there was practically no rain till Septemeber and then 4 inches of rain in one day. Older weather records recall a different state of affairs when the rainfall was slightly heavier, 27 inches, circa 1900 A. D. and distributed over no less than 70 days. Ahmednagar district lies to the east of the Western Ghats and most of the moisture brought over by the south-west monsoon from the Arabian Sea is precipitated on this mountain barrier. Ahmednagar district receives higher rainfall than other districts of the Deccan like Sholapur and Bijapur because of its hilly nature. The monsoon season is followed by a mild winter and a long dry summer when desiccating north-east winds prevail. Summer is usually a period of drought and the climate grows exceedingly dry till the break of monsoon in early June.

Rock and Soil

The underlying rock is more or less uniform throughout the district and consists of varieties of basalt of the Deccan Trap type. Some varieties with a reddish brown colour are readily weathered while dark grey and black varieties are very resistant. The former give rise to a detritus which is soft when freshly cut but froms a hard friable mass popularly known as murram. Red soils are often met with at the foot of hills and is often deep and fertile. The greater part of the soil is of the black cotton type and calcareous loam or mixtures of the two. Where deep, as along the banks of the Godavari river, the black cotton soil is very fertile and fine grain crops as well as tree growth is met with. Calcareous loam is somewhat less fertile but supports a good growth of *babul* (*Acacia arabica*) on the Bhima water-shed area, and the skeletal murramy soil met with on hill slopes and endless barren plains locally known as *mals* is not at all congenial to tree growth. On these 'mals,' the surface soil is

washed off and the remaining soil is much compacted by trampling of cattle and goats. In the low-lying areas cultivated lands tend to become silted up with a gravelly deposit washed from the adjoining waste lands with a deleterious effect.

Irrigation and Canal Systems

The dry nature of the countryside has already been stressed and due to this feature the importance of irrigation by canals attains a high order. The present day canal system is confined to the north-east portion of the district, and though quite inadequate to meet the vast demands of the district, it is responsible for a very large percentage of the district's foodgrain and sugarcane crops. There is however ample scope for expansion and development.

Recent History of Reserved Forest

The legal position of forest lands was assured by a settlement shortly after the Forest Act of 1878 was introduced and from then onwards the areas were controlled by the forest department. The best wooded areas were divided into blocks and compartments in the year 1890, regeneration being carried out by sowing *babul* (in ploughed land) at a cost of Rs. 2/- to Rs. 4/- per acre. The results were unsatisfactory and the areas for the most part remained unregenerated. The area covered by the working plan was 25,862 acres about 1/20th the total forest area. In 1901 a definite working plan was drawn up by Mr. R. S. Fagan, the then Deputy Commissioner of Forest. The working plan was presumably in force up to 1910 when all the land was handed over to the revenue department, except certain areas in the Sangamner and Akola *talukas* which up to now are under the control of the D. F. O. West Nasik Division and worked under the working plan of that division. A working plan for this area, the working plan of Ahmednagar Teak Forest was drawn up by Mr. J. Dodgson in 1904 and the proposals made therein are of interest as they indicate the nature of forest growth then in existence. To this day this area shows exceptional forest growth compared to other areas not under forest department control; showing by a sharp contrast effects of protection. A brief survey of the nature and extent of forest growth circa 1901-1904 will not be amiss as it will show clearly the effects of destructive influences at play up to the present day. On referring to Mr. Fagan's working plan of 1901 which covers a large portion of the district it is found that he describes to be as "good" or "good passing to sparse" the areas which are now totally devoid of tree growth. He further goes on to report for *babul* a height growth 45-50 ft. and. d.b.h. of 20 in. for 40 year old crop. Such growth to-day is very exceptional indeed. No mention has been made of the wide "open spaces" which are typical of the countryside to-day. All this goes to show that during the last 40 years or so disforestation has been progressing at an alarming rate and has resulted in utter devastation. The forest areas in Sangamner and Akola *talukas* which to this day present good forest growth also were in a much better state at the turn of the nineteenth century. Fellings in this area were carried out as far back as 1864 and in the year 1879-1880 Mr. Hight drew up separate working plan of the forests in Sangamner and Akola in which he proposed the system of clear coppice cutting with the reservation of standards left to the discretion of the local D. F O. In the year 1895 Mr. Osmaston drew up provisional working plan for Sangamner and Akola forests and in it he suggested a 40-year rotation and the reservation of a certain number of standards per acre was fixed. Working under Mr. Osmaston's plan the following revenue figures were obtained :—

Year	Area felled	No. of trees felled
1896-97	1,652 acres	23,587
Expenditure	Receipt	Net revenue
Rs. 941	Rs. 6,847	Rs. 5,906

The net revenue per acre worked out at Rs. 3-8-0. Mr. Dodgson's working plan of 1904 is based on the lines of Mr. Osmaston's plan and reiterates his proposal of a 40-year rotation under coppice with standard system and planting up of blanks. In this working plan it is proposed to plant *ain*,* *dahavda*, *khair* on deep soil and *neem*, *sirus*, *bor*, *khair* and *dhavda* on poor rocky soil so as to have forest cover. It is not possible to-day to ascertain how far these plans were successful, but one fact stands out above the rest and that is that the forests have undoubtedly deteriorated. The fact that executive officers failed to carry out the prescriptions and the population made heavy inroads into the forests however is evident to this day.

Destructive Influences

The destructive influences which brought about the devastation of large tracts of forest lands within the course of 40 years may be summed up as indiscriminate grazing and wanton cutting and lopping. Since the handing over of the forest tracts of the greater part of the district to the revenue department in 1910 no control whatsoever was exercised in respect of grazing except the levy of a certain fee. The village population was entirely at liberty to misuse and abuse forest land according to their own whim and choice. This freedom of grazing has bred in the peasants a spirit of extreme wantonness and indiscipline and they are apt to consider it their birthright to be able to spread destruction around them as they please. Land there is enough and more than enough, to meet their frugal needs

if properly maintained. It is, however, now so devastated by their own misdemeanour that it is incapable of supplying a tenth of what is required for a bare living. Educating the peasants by a vast propaganda campaign, so that they are able to realise what is required of them for their own welfare is, in my opinion, the first essential of an afforestation plan and this would best be accomplished by agents of a popular government in whom the masses repose their trust. In the absence of the co-operation of the peasants any constructive work is open to abuse by them and it is futile to try to enforce stringent measures over so vast an area which is moreover dotted all over with cultivated plots. The forest department would thereby reap only a grey harvest of wide unpopularity. Lopping trees and even saplings and bushes both for goat fodder and brushwood is a highly injurious practice and its detrimental effect is far in excess of any produce it is likely to yield.

Grazing Situation

The present grazing situation is indeed critical, the land having so deteriorated as to yield the minimum of coarse stubby grass, certain varieties, *e. g.*, spear grass being not eaten by cattle. Furthermore, as there is no control whatever over grazing the animals nibble at and trample over the tender shoots of grass as it begins to sprout at the beginning of the rainy season. The deleterious consequence of this is twofold; firstly it effectively prevents the grass land from giving its maximum yield and secondly, the trampling renders the soil an easy prey to erosive action thereby impoverishing it year after year. It has been experimentally established beyond doubt that the benefit obtained from dung manure in such cases is not worth consideration. The extent of overgrazing can be judged from present day figures which show (1) horned cattle or 8 sheep or goats per ½ acre as allotted by the revenue department for grazing, whereas the growth is such as would easily require 3-4 acres depending on the site yield sufficient grass to maintain 1 horned cattle or 4 sheep or goats. In an extreme case, in Kanhoor village in Parner *taluka* there are 3,624 cattle and only 200 acres of forest land. What colossal over grazing this figure envisages. Sangamner and Akola are the only *talukas* where the land is in excess of grazing requirements. In Shevgaon *taluka* out of 131 villages, 126 villages have grazing area below 1 acre per horned cattle and its equivalent of 8 sheep or goats. Grazing by goats is far more injurious than cattle grazing. The goats nibble the lower branches of trees and even climb trees to get at their foliage and besides, it is reported that once a goat nibbles seedlings they wither and die off.

Loppings and Cuttings

The ills born of indiscriminate loppings and widespread irresponsible cuttings are manifold. Firstly, whatever shade and cover tree and shrub growth provides is reduced to a minimum and gnarled and stunted trees result. The growth is very adversely effected and the growth is kept at a low level for a number of years. The vegetation begins seeding prematurely and the seed though often prolific is not always fertile. It is a habit among villagers to collect brushwood which is light to carry and easy to burn. This naturally results in less fuel being obtained than if the trees were allowed to grow and then cut. The saplings which in any recognised forest practice should be allowed to grow unhindered are thus damaged and destroyed. This activity prevents any appreciable tree growth coming up and is the bane of the countryside. It is certainly true that there is a general shortage of firewood and fuel but this practice only tends to aggravate the situation. Throughout the district cowdung cakes are used as a fuel, this practice depriving the soil of the manure which rightly should go into it. At the moment it is imperative to import firewood from districts where there is great abundance such as Belgaum and Dharwar districts and make it available to the peasants at a reasonably cheap rate if this highly injurious practice is to be effectively checked. The following figures of fuel consumption will give a fair idea of the destruction caused. Ahmednagar city alone requires 21,425 tons of firewood annually and Rahuri a small *taluka* 4,200 tons.

Tree Growth Conditions

Before going on to the consideration of the work recently proposed by the forest department and any plan for afforestation of the district it will not be out of place to take stock of the existing tree growth of the district. Starting from the N. W. corner, one finds reasonably good tree growth composed of fine tall trees up to 50 ft. and over with straight boles. This area is under forest department control and teak is found mixed with Anogeissus, Pterocarpus, Apta, Butea, Albizzia, *Careya arboreya*, etc., the common associates in a dry tropical deciduous forest. On leaving the protected areas the growth suddenly grows sparse and stunted though factors governing tree growth do not exhibit any abrupt change. Barren hills form a regular feature of the countryside and the effects of erosion are widespread. On entering the plains the prospect is as bleak and except for the green patches of cultivation the plains present an uniformly barren brown aspect. The stunted trees are few and far between and in a miserable state. *Neem* is the only tree which shows good growth almost anywhere. The stunted growth consists mainly

of *babul, khair, apta, karanj, Palas, bor* and Euphorbias. Among the shrubs the common ones are *tarvad, hivar, amoni* and *sissal* or Agave. Hedges of Agave and Euphorbia are often met with nearly always on the edges of cultivation.

Recent Developments

A forest department establishment has been set up in the district since January 1946, under the control of an able Sub-D.F.O. and it is proposed to take over suitable lands from the charge of the revenue department and afforest them. The department has done much useful work within the short time, but it is essentially of a preliminary nature. The major part of the district has been carefully surveyed and suitable areas have been selected, and concrete proposals have already been made for their afforestation. These proposals have been accepted by the government and work will shortly be taken in hand. The aim of the afforestation work proposed is to bring about a general improvement in tree and grass growth and prevent further erosion taking place with the minimum of expenditure and within as short a time as is compatible with the nature and extent of the work. The total area of reserved forests in the districts is 5,06,223 acres of which 1,23,419 acres are already under forest department regime and regularly worked. The area to be impoved and afforested is 3,82,774 acres of reserved forests, *gairan* (pasture lands) area is 44,189 acres and revenue waste lands 12,609 acres. The magnitude of the task can easily be gauged by these figures. Villages with more than 200 acres of land are selected for afforestation either to be left in charge of the revenue department or handed over to the land improvement department which can deal with them more efficiently.

Proposals for Afforestation

The proposals, although they keep the long term improvements in view, are essentially made on a short term basis of concentrated working. The duration of concentrated working is presumably 10 years in all except a very few cases. The proposal first considers, and rightly too, protection in the way of controlled-grazing and prevention of widespread cutting and lopping by rendering these acts illegal. Since land in the vicinity of villages must always be available for grazing the cattle of that village the proposals envisage a scheme of controlled rotational grazing with each village as a unit. The extent of grazing to be permitted is obviously dependent on the land available and greater or lesser closure is applied according to the conditions obtaining. In many cases where the land available is far short of grazing requirements it has not been possible to propose total closure at all in any part of the area without causing the peasants much hardship and so it has been proposed to divide the area in two parts closing one for 4 months of the monsoon in turn every alternate year and broadcasting good grass seed; and, opening both in the dry season if required. It is thought that thereby the evils of overgrazing will be greatly reduced and *slow* improvement will take place.

It has been noticed by forest department authorities that of the land given out for cultivation as much as 40 per cent. in some areas lies fallow and it is universally observed that no improvement or even preservation works such as gully plugging, bunding, etc., have been carried out by the cultivators. Furthermore, in-forest cultivations, a multitude of which exist today, should be taken over by the forest department as, if allowed to remain as at present, an untenable position would result and the protection of forests round about would become a hopeless task. Findings of the forest department show that much unsuitable land was given out for cultivation under the 'Grow More Food' campaign during the war and that much of it has been damaged through misuse and neglect. It is proposed to take over in-forest cultivations and all land unsuitable for agricultural purposes at present under cultivation and afforest it by the agri-cum-silviculture or *taungya* method.

In order to make provision for fodder for local consumption or export to deficit areas it is proposed to reserve plots, in areas where forest land is in excess of cattle requirements as, *kurans* (grasslands) with permanent closure and a little improvement in the way of introducing better quality grass and some tree growth at a cost of Rs. 4/- per acre.

In some parts of the district cattle from outside the district migrate into it as in Parner *taluka* where cattle from Kokan graze from June to November and it is proposed to control such animal movements. Since it is not feasible to apply total closure to the whole area to be afforested the following plan is proposed. The area is to be divided up into 4 parts. One part being totally closed for 5 years after planting and sowing and the 3 remaining parts opened for grazing for 1½ months at a time up to March after which all three may be thrown open to grazing if required. Thus it is expected to improve soil conditions in these 3 parts prior to planting or sowing up.

On an intimate study of the conditions of the land, it has been found that extensive land improvement works of an engineeing nature are not really necessary and it is proposed to carry out contour-trenching, bunding and gully-plugging operations only where erosion has been really heavy. The greater part of afforestation is to be carried out by dibbling seeds and agri-cum-silviculture or *taungya*. Dibbling

of seeds in furrows 6 ft. apart is to be carried out in good fertile soils, the land being ploughed whenever possible. Agri-cum-silviculture or "agri-silvy" method is to be applied to lands already under cultivation or land which is otherwise suitable for cultivation and by this method it is proposed to sow seeds in rows 24 ft. apart and plants 4-6 ft. apart in each row. Tending and weeding is to be carried out but no thinnings are thought necessry. A certain area is to be maintained for rotational grazing.

Cost

It is estimated that the cost of contour trenching will be Rs. 12/- per acre; of bunding Rs. 10/- per acre, of afforestation by dibbling seeds including weeding and some gully plugging Rs. 8/- per acre and of grass improvement Rs. 4/- per acre. To obtain a full idea of the work proposed let us consider an example. Karjat *taluka* has 50,499 acres of reserved forest, *Gairan* and waste lands, of which 46,027 acres are selected for afforestation. Of these 17,285 acres are to be afforested by agri-silvy, 13,908 acres by dibbling suitable seeds, and 5,146 acres for contour trenching, bunding, etc., most of which area is along hilly slopes; and 7,476 acres are to be maintained for rotational grazing. The total cost of this improvement work extending over 10 years is estimated at Rupees five lacs approximately including establishment charges. When one considers that Karjat is one of the most dry and barren *talukas* of the district an expenditure of 5 lacs for its afforestation is not a sum to be grudged. One can only wish that it will be satisfactorily afforested within that sum and within that short duration.

Choice of Species

The choice of species to be employed for afforestation is based on the stunted growth found scattered over the areas to be afforested. Generally speaking, it is proposed to plant *anjan, khair, neem, dhavda, sisham, babul, apta, karanj, jambul* and Palas in good soil and 'agri-silvy' areas whereas in poor dry soils it is proposed to broadcast *neem, bor, khair, karanj*. Of these *khair, babul* and *anjan* leaves can be used as goat fodder in times of famine. In order to carry out plantings, especially in refractory areas, nurseries are to be raised adjacent to canals from which water supply can be readily available, and it is proposed to fence these nurseries with barbed wire. Sites have been selected of which one at Devlali village in Rahuri *taluka* may be mentioned. Further it is proposed to set up an experimental and research station at Dongargan in Ahmednagar *taluka* where stream water supply is available throughout the year and some good tree growth already exists. Since all types of country met with in the district are thought to be represented near about this place, it is proposed to carry out tests as regards the suitability of different species for various conditions and the technique to be applied in each case. This experimental station is to be under the control of the silviculturist of Bombay province.

Results expected off the Present Scheme

The above consideration of the scheme of afforestation proposed by the forest department indicates that if the scheme is successful within the next decade or so the forests of Ahmednagar district will be well stocked and the now naked land draped in a pleasing canopy of green. Erosion will not only have been definitely checked but altogether stopped due to a generous soil cover. A considerable change in the condition of cattle is also to be expected and better conditions for raising agricultural crops should also result. The period of drought during the hot season would diminish if not disappear and lakes and rivers seldom or never run dry. Within a couple of decades the forests would be in a position to supply all the firewood and small timber requirements of the villages such as for making ploughs (which by then should be obsolete) cart-wheels etc. The revenue accruing from forests of this district within the next three or four decades should easily bear out the comparatively small initial expense of afforestation although the primary aim of these forests in the not too distant future is to provide soil cover and meet the fuel and grazing requirements of the population besides enhancing agricultural conditions by their indirect effect.

Some considerations

So far we have considered the scheme drafted by the forest department for the afforestation of the district and though its goal is laudable and the results achieved if it is cent per cent successful indeed very pleasing. One cannot however be free from a haunting doubt as to whether it is comprehensive enough to bring about the total afforestation of such wide and barren dry tract of land. Are we not leaving too much to nature and expecting a great deal more from it than circumstances warrant? It is true enough that protection enforced or natural as in the case of Lakhiphal forests on the banks of the Godavari, in Shevgaon *taluka*, has resulted in good growth being maintained, but that evidence would be misinterpreted if it is considered that areas disforested many years back will react so favourably to protection and will readily support tree growth even of hardy species. Those responsible for the birth of the afforestation scheme are doubtless aware of its limitations but they feel that without extensive irrigation and other land improvement

works, this is the best solution to the problem. At some date say 25 years hence there will be a vast difference between what has and what may have been. Let us therefore, consider what can be achieved with an all out effort on the part of the government and what would then be the future of the forests of Ahmednagar district.

Long and Short term Schemes

The solution of the afforestation problem clearly lends itself to a short term and a long term plan. The former dealing with areas with existing tree growth and fully stocking them and afforestation both by agri-silvy and planting and sowings in rich soil which ordinarily retains moisture and the latter treating badly eroded and dry areas contour-trenching, gully-plugging, bunding etc., would be carried out and followed by gradual afforestation along with grass, shrub and tree growth. Indeed both the plans should be taken in hand with the minimum of delay and a vigorous policy pursued in respect of both.

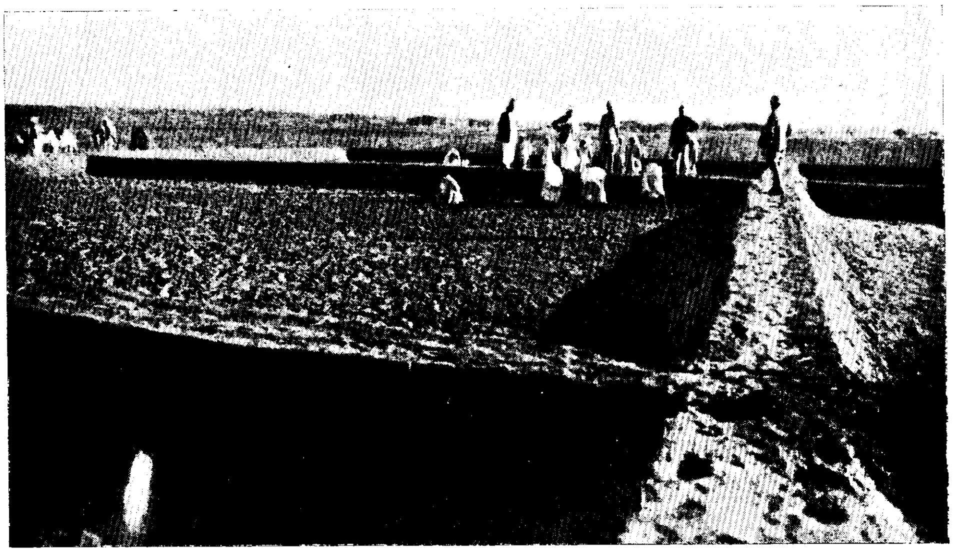
Co-ordinated Schemes

It is only when the schemes for afforestation move hand in hand with large scale schemes for irrigation and general land improvement that it is possible to attain really substantial measure of success. An average annual rainfall of 20-inch is sufficient to maintain a dry deciduous forest and it should be the aim of any well laid plan to conserve every drop of moisture. Land almost everywhere is fertile and will support one kind of tree growth or another if only enough water were available. The water-table is not too low for many deep-rooted species and watering of plants is required only for the first 3-4 years in normally grown plants. Roadside avenues, the avenues of *sisham* trees along the Manmad road from 8-12 miles from Ahmednagar provides a fine example, are a clear indication of what fine growth may result if seedlings are watered in the initial stages. At Dongergaon though the terrain is rocky there is abundant and luxuriant growth due to spring water. All this goes to show that water is the first essential for any tree growth. The heavy floods in rivers of this district shortly after a heavy downpour are a sure indication of the heavy drain off. The rivers to the north-east *viz.*, Godavari, the Pravara and the Dhor and to the south-west *viz.*, the Bhima, the Ghod and the Sina of the median hill range can effectively be bunded or dammed so that a large proportion of the water is withheld. There exist several suitable areas where this water can be stored in the broad basin of the river and distributed by canals to the surrounding parched country. A larger amount of water would remain flowing in the rivers and their tributaries and this can be tapped by the peasants wherever required leading it away by means of small channels. This practice is very successfully carried out in a hilly country like Chakrata where a meagre hill stream is taken as the source, so it could surely be employed both for agricultural and forestry purposes in this district. A network of canals could furnish the sloping plains on both sides of the hill range with sufficient water at least during the monsoon season. Several suitable catchment areas simply await bunding and these can serve as lakes with water in them even in the dry season. Irrigated plantations steal a march over any other type of afforestation work and the possibility of raising them should, in my opinion, not be neglected. The irrigated plantations of Changa Manga in the Punjab are an excelleant illustration of the fine work that can be carried out. As trees grow it would only be necessary to water them only in the dry season and then not at all. Bunding of streams and rivers would also lead to a general rise in the watertable, and as growth increases drainoff would diminish creating a very favourable set of conditions.

Not only irrigation but judicious agricultural works would help immensely; the raising of fodder crops and food grain crops providing fodder such as *jowar* would effectually lessen the burden of grazing and at least 20 per cent of cultivated land should raise fodder crops. It should definitely be borne in mind that for the duration of these improvement schemes it would be necessary to import even to a larger extent perhaps fuel and food grains from surplus areas. It is hardly possible to resuscitate land whilst drawing out of it every single grain or blade of grass it can yield.

To discourage heavy drainoff and allay erosion of surface soil gully-plugging is a successful measure provided large stones and boulders employed do not entirely stop the flow. On gently sloping ground hedges of agave, *sissal* and some zerophytic euphobias form an effective screen. Contour trenching may be resorted to on steep slopes heavily eroded but is not fit for general application. Prof. Stebbing quotes an Indian C. C. F's tour notes thus "Trenching is far too expensive to be done on large scale and dams though certainly useful are hardly required at this stage, (about as bad conditions as obtaining anywhere in this district) as the greatest success is being obtained by simple closure. Even this very broken ground is producing a crop of grass and bushes which will be of local value in addition to serving as check to erosion". Here we have an authoritative view on the subject and it should be best to allow the barren hill slopes to put on a cloak of grass, some aid being furnished by way of broadcasting good quality grass seeds and seeds of some hardy shrubs like *cassia auriculata* and *cassia tora* and trees like *babul, palas, bor,*

Fig. I



Sunken bed nursery ready for broadcast sowing of **sissoo** seed on the damp earth exposed by scraping away the surface.

Photo: R. M. Gorrie.

Fig. II

Sunken bed nursery with 18 month old plants many of which are fit for winter stump planting. Kotla, Gujrat.

Photo: R. M. Gorrie.

Thus the long term and short term schemes operating simultaneously and with the same urgency but in different areas would with the aid of other land development schemes fructify into a totally afforested area. The short term programme would in a way act as a relief measure while the long term scheme is in operation in areas requiring greater weaning, and would also deal in a concentrated manner with areas more likely to respond and which, if treated uniformly under one long term scheme, would tend to be neglected or rather not fully taken advantage of. It is not possible to go into the details of operation of these two schemes but the short term scheme would be very similar to the present forest department proposals with a few exceptions already mentioned. *Babul* mixed with *Khair* would form a major portion of the forests in the first instance, as *babul* is growing even at present. *Khair, kansar, anjan, ghatbor, bor* etc. should be widely introduced as they are hardy species. On better soils, *sishim* Anogeisus, *diospyrus*, Bauhina, *Cassia seamia, Aegle marmalos*, mango, *nim, karanj* etc. should be introduced. *Sisham* as already pointed out is doing well as avenue tree. Another species worth mention is Santalum also which is found gregarious though widely scattered, and there are indications that if properly cared for and furnished with an appropriate number of host trees such as *cassia seamia*, this species would flourish. It would fetch a very good revenue being more highly priced than even Burma teak. Scholars and bards of ancient times have sung of the beauty and grandeur of the forests which then existed in this district. Legend of many romances enacted by Ram and Sita in these forests are current to this day. It may take centuries to reach that state again or may be the geological and other factors have so changed as to make such a reversion impossible, but with a co-ordinated and spirited effort it should be possible to change the face of countryside beyond all recognition, clothing it decently in a gay garb of forest greenery.

Glossary

List of common trees and shrubs found in Ahmednagar district.

Vernacular name	Botanical name
Apta ..	.. *Bauhinia racemosa.*
Ain ..	.. *Terminalia tomentosa.*
Aoli ..	.. *Phyllanthus emblica.*
Amoni ..	.. *Rhus parviflora.*
Amba ..	.. *Mangifera indica.*
Babul ..	.. *Acacia arabica.*
Bel ..	.. *Aegle marmelos.*
Bor ..	.. *Zizyphus jujuba.*
Chinch ..	.. *Tamarindus indica.*
Dhavda ..	.. *Anogeissus latifolia.*
Dhaiti ..	.. *Woodfordia floribunda.*
Ghaneri ..	. *Lantana camara.*
Ghatbor ..	.. *Zizyphus xylopyrus.*
Hekal ..	.. *Gymnosporia Montana.*
Hiwar ..	.. *Acacia leucophlea.*
Jambhul ..	.. *Eugenia jambolana.*
Karanj ..	.. *Pongamia glabra.*
Khair ..	.. *Acacia catechu.*
Kansar ..	.. *Albizzia amara.*
Nimb, Neem	.. *Azadirachta indica.*
Pallas ..	.. *Butea frondosa.*
Sag ..	.. *Tectona grandis.*
Sabri ..	.. *Euphorbia Neriifolia.*
Sisham, sissoo	.. *Dalbergia latifolia.*
Sirus ..	.. *Albizzia Lebbek.*
Sissal ..	.. *Agave species.*
Savar ..	.. *Bombax malabaricum.*
Tarwad ..	.. *Cassia auriculata.*
Wad ..	.. *Ficus bengalensis.*
Pipri ..	.. *Ficus religiosa.*
Nirguri ..	.. *Vitex negundo.*
Temburni ..	.. *Diospyros melaoxylon.*
Ruti ..	.. *Calatrapis gigntea.*
Sundal, chundni	.. *Santalum album.*

UNIRRIGATED SUNKEN BED BELA NURSERIES IN GUJRAT SOIL CONSERVATION DIVISION

BY KHEM CHAND

(*Divisional Forest Officer, Soil Conservation Division, Gujrat*).

In *bela* closures, unirrigated, sunken bed nurseries over 42 acres have been laid out and sown with *shisham* (*Dalbergia sissoo*), etc., during 1944-45 and 1945-46; and the results are encouraging (*vide plate* 29). Such permanent, unfenced nurseries should be a feature of *bela* closures. Well-irrigated, fenced nurseries on hired lands are comparatively much too costly and uncertain. For subsequent instalment, the closure-nursery will be still cheaper. The out-turn will be about $1\frac{1}{2}$ lacs of stumps and transplants per acre. Total cost for the first instalment is Rs. 600/- per acre (including farm manure) at war rates, and for

Technique

A suitable site in a moist locality of a well protected *bela* closure, immune from floods, should be selected. The required size (say, 1 acre) may be demarcated on ground. The outer and inner *patries* (embankments) to serve also as inspection paths (8 ft. and 6 ft. wide respectively at the base), will be pegged out and *dagbeled* (marked). The area may then be excavated to a depth of 9 in. to 18 in., according to the degree of moisture available in the soil, with plough and *karah* (earth scoop) or spade. The spoil-

Finally, levelling and dressing of the beds and inspection paths, raised into *patries* (embankments), will be done. The embankments also serve as protection against floods from the torrent. The nursery will consist of a number of compartments, each, say, of 1 *kanal.* These will be ploughed up and manured at the rate of 30 bagfuls of farm manure per *kanal.* The work so far should be finished by December.

Shisham seed may then be sown broadcast in February after the winter rains, and the plough furrows partially levelled up with light *sohaga.* Mulberry, mango, *jaman* (*Eugenia jambolana*) and *bakain* (*Melia azadirach*) may be sown in blanks at the commencement of monsoon. The nursery will be ready for extraction of *shisham* stumps in July—17 months after the sowings. For the subsequent instalments of raising plants and stumps only manuring will be required but no excavation.

EXTRACTS

HOW ARE THE GREAT PLAINS SHELTERBELTS? *

E. N. MUNNS AND JOSEPH H. STOECKELER

Chief, Division of Forest Influences, Forest Service, Washington, D. C., and silviculturist, Lake States Forest Experiment Station, St. Paul, Minn., respectively.

Data presented here give details of survival and growth of the shelterbelts planted from 1935 to 1943 by the U. S. Forest Service in its Prairie States Forestry Project and by the Soil Conservation Service. The information is based on a systematic survey of 1,072 belts. The outstanding features brought out are the widespread interest of farmers and ranchers in the program, the better-than-expected survival and growth, a wide variety of benefits and values already derived from the comparatively young belts, the great importance of adequate cultivation, and some interesting silvical and management problems that are beginning to show up.

Most foresters remember the Prairie States Forestry Project as America's most controversial forestry project.

The P.S.F.P. had its origin in the mind of President Franklin D. Roosevelt when in 1932 he was wreck-bound before a smelter-denuded slope near Butte, Montana. It was not until the drought and dust storms of 1934 that the answer to his early query, "What can be done to plant the Great American Desert?" took the form under which the project was subsequently developed. Its chief purposes were, through tree planting, to ameliorate drought conditions, protect crops and livestock, reduce dust storms, and provide useful employment for a drought-stricken people. Throughout its life, the project was developed so as to provide a maximum of relief to the residents of the drought-stricken area. It operated almost exclusively on relief funds and was subject to all the difficulties attendant upon such financing. It began as a drought-relief measure and ended when the Works Progress Administration (W.P.A.) finally closed down.

No sooner had the project been announced than foresters took sides†. Many, without faith in the technical skills and attainments of the profession, viewed the project with alarm. Others, among them many "experts" denied that trees could be made to grow on the desolate prairies, and foredoomed the attempt to failure. Few of the doubting Thomases knew first-hand of conditions in the Plains, attempted to discover the physical basis behind the plan, or proffered their skills to the undertaking.

The proponents, however, affirmed that trees not only would grow but would exert a powerful influence on the climate of the immediate locality. They had accumulated evidence to support their belief that belts of trees would have measurable beneficial effects on wind velocity, evaporation, and temperature, and would thereby aid in conserving moisture, reducing wind erosion, and preventing dust storms. They supported their contention by existing plantations on old tree claims and shelterbelts from 40 to 60 years of age and up to 80 feet high.

Before actual work on the project started, a comprehensive investigation of the Plains States was made to work out the details. In this study the climate, soils, ground water, vegetation, land use, and kind of trees that had proven successful were taken into account.‡ A review was also made of all available information on this type of planting, and data were sought from all foreign countries where shelterbelt planting was known to have been done. With this information at hand, the boundaries of the shelterbelt zone (Fig. 1) were rather definitely determined, the species to be used were selected, and the methods and techniques generally established.

Now that the Shelterbelt Project as such is no more and it is 10 years since the first belts were planted, it is timely to see how the plantations look, how the trees have withstood the rigors of drought and storm and of heat and cold, how the belts have developed, and whether they have accomplished any of the purposes for which they were established. To discover the answers to such questions a general survey of the plantations was made in the summer of 1944.§

*Two articles on shelterbelts were reproduced in the *Indian Forester* for September 1945 and February 1946.—*Ed.*

† See discussions in *Journal of Forestry* Nov. and Dec., 1934.

‡ Possibilities of shelterbelt planting in the Plain region. 201 pages, 196 figures. Govt. Printing Off., Washington, D. C. 1935. Prepared under the direction of the Lake States Forest Experiment Station.

§ The writers are indebted for help on the 1944 shelterbelt survey to A. E. McClymonds, regional conservator, and Ross Williams, regional forester, S.C.S. Region 5; Louis P. Merrill, regional conservator, and Homer C. Mitchell, regional forester, S.C.S. Region 4; Herbert Wells, forester in Oklahoma for S.C.S.; the late F. E. Cobb, in charge of farm forestry for the S.C.S. in North Dakota; and Glenn Durrell, state forester of Oklahoma. Credit is also due to the various state directors of the S.C.S. from North Dakota to Texas as well as to numerous district conservationist-

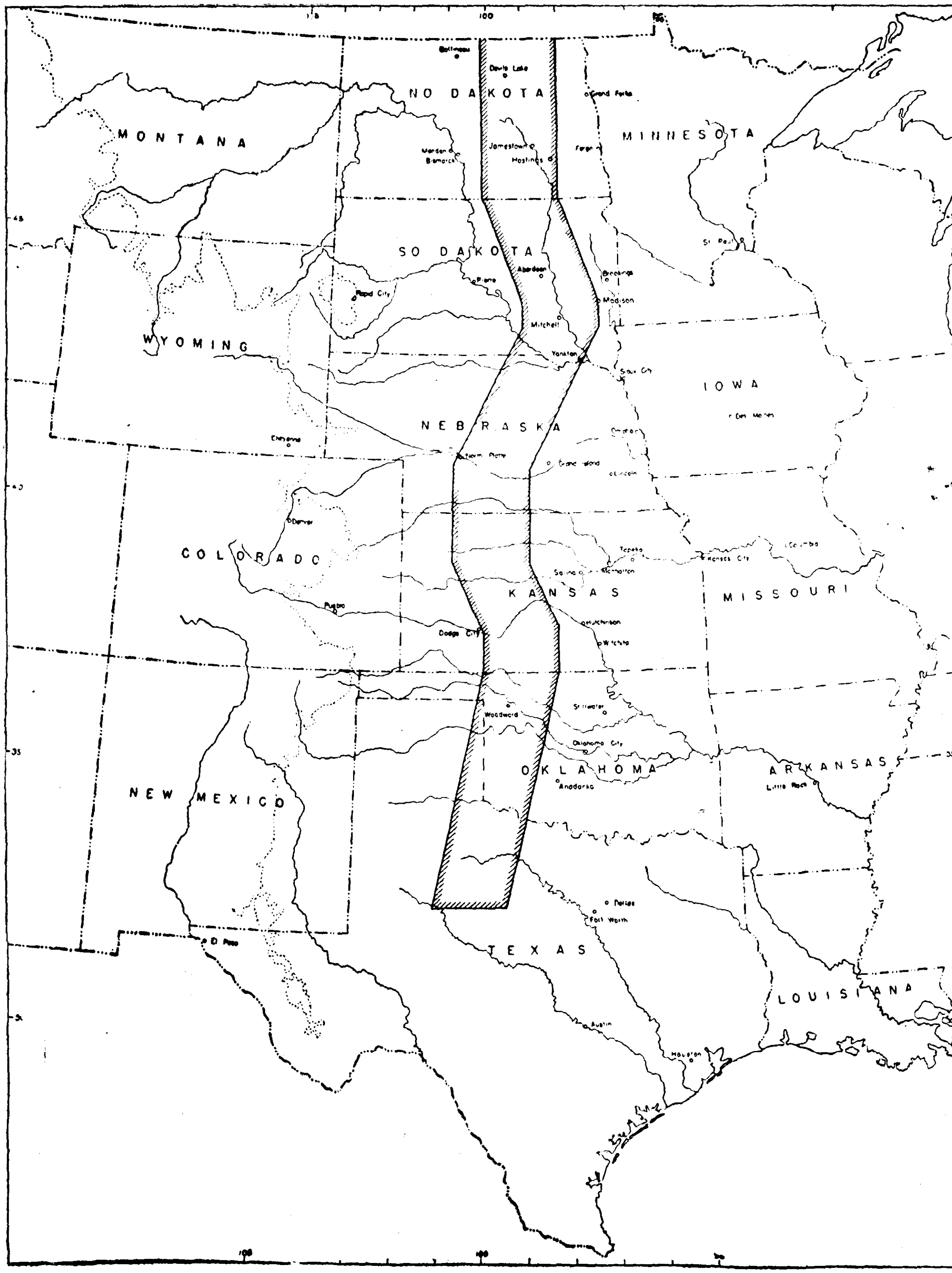


Fig. 1—Approximate location of shelterbelt zone in which most of the Prairie States Forestry Project was developed. Some plantings were made outside of the area shown.

The Survey.

The shelterbelt survey of 1944 was a random sampling of the area. It reached into every state and into a total of 93 counties. In all 1,079 belts were examined. These made up 2.7 per cent of the total mileage (18,600 miles) and 3·6 per cent of the total number of belts (30,223) planted from 1935 to 1942 inclusive. The sampled belts included over 3 per cent of the total number of trees planted (220 million) on 238,000 acres.

In addition to sampling the project plantings of the U. S. Forest Service some records were also taken of shelterbelts established by the Soil Conservation Service including a portion of their 1943 plantings which amounted to several million trees * of these personally planted by farmers in the shelterbelt zone during the project period and of those made by the states to protect highways from sand or snow drifts. The full length of the shelterbelt zone was traversed twice. Data were taken on all belts along the line of automobile travel which followed a zigzag route to sample many counties and townships. Practically every belt along the route was examined including those which had failed or had been destroyed. Careful search was made for missing belts since failures often provide more information of value to future work than successes. In sections with a large number of belts many successful ones (probably in excess of 100) were passed by because age class composition growth rate and soils in that area had already been adequately sampled. This sampling has made the results conservative.

Data on age appearance and other characteristics were recorded for each belt with notes on surface and subsurface soil water table, and damage by various causes. Special attention was given to the amount and character of cultivation and care given the belt and when this cultivation took place. For each row in the belt specific data were taken as to height, diameter, crown spread, survival, vigor, crown class, closure of canopy, ground cover, continuity of row, and seed production for each species. If the row had been replanted, comparable data were taken on the replanted trees. If the original rows had been removed, an effort was made to determine the original species and when the trees were taken out.

Characteristics of the Belts.

Belts were planted to meet the desires of the owner and the requirements dictated by the prevailing winds, and not in any set geometric pattern. Consequently most belts were on property lines and usually in an east-west direction. They varied in length from 1/8 to a full mile, with occasional strips up to 2 miles in length as a result of continuous planting by owners along the same land line. The length of an individual belt was in most cases limited by farm size; thus, 57 per cent of the belts were 1/2 mile in length, indicating a 160-acre farm, and 22 percent were $\frac{1}{4}$ mile long, indicating a 40-acre or 80-acre farm.

Most farms had but one belt, though a number had a second planted at right angles to the first for better protection. Some of the larger farms, 640 acres, had belts completely around them, and an occasional large farm was broken up into blocks of from 30 to 60 acres by interior belts. Some farmers in the sandier and windier sections planted an interior belt, breaking up 160 acres into two 80-acre fields. In some area where fruits were grown, orchards or vineyards of from 5 to 20 acres were practically enclosed within belts.

The number of rows per belt varied from 1 to 23. Some 56 per cent of the belts sampled were 10-row plantings in which from 5 to 8 different species were used, 1 or 2 rows being of 1 or 2 species of conifers. A fair number of belts contained 4 and 5 rows, but only a very few, mostly early, belts, had over 20 rows. These larger belts contained from 8 to 16 different species, the greater number of species being found in belts where more than one species was planted per row. A relatively small number of belts—mostly planted for experimental purposes by the Lake States Forest Experiment Station—were made up of only 1, 2, or 3 rows.

The belts had two basic cross-section patterns. The earlier plantings were symmetrical, with the tallest growing trees in the centre flanked by shorter trees, and tapering off to shrub rows on each side. A fairly typical example of such a cross-section along with average height of trees is given below for a 9-year-old planting in Davison County, South Dakota:

Row 1, lilac, 2 feet; row 2, caragana 4 feet; rows 3 to 5, green ash 12 feet; row 6 honeylocust, 20 feet; rows 7 and 8, American elm, 12 feet; row 9, Siberian elm, 22 feet; rows 10, 11 and 12, cottonwood, 25 feet; rows 13 and 14, Siberian elm, 21 feet; row 15, honeylocust, 18 feet; rows 16 and 17, green ash, 12 feet; row 18, American elm, 12 feet; row 19, wild plum, 8 feet; row 20, caragana, 4 feet.

*The action program in the project from 1935 to 1942 was supervised by the U. S. Forest Service and was known as the Shelterbelt Project or Prairie States Forestry Project. From 1943 on, the work of the project was taken over by the Soil Conservation Service.

The other pattern, adopted after the project was well under way, was asymmetrical in cross-section with fewer rows. The slower growing and more permanent species were in one half of the belt and the faster growing in the other half. A typical example of such a cross-section along with average height is given below for a 6-year-old shelterbelt in Knox County, Nebraska:

Row 1, Siberian elm, 20 feet; rows 2 and 3, cottonwood, 26 feet; row 4, honeylocust, 18 feet; row 5, American elm, 15 feet ; rows 6 and 7, hackberry, 12 feet; row 8, green ash, 10 feet; row 9, ponderosa pine, 3 feet; row 10, caragana, 4 feet.

The belts examined ranged in age from 2 to 10 years and averaged almost 6.5 years. The average height of all belts in 1944 at this age was about 16 feet in North Dakota, 20 feet in Nebraska, and 24 feet in Texas.

Rows in belts were spaced mostly from 8 to 10 feet apart, but in some places the rows were 12 feet and rarely 14 feet apart. All the rows in a belt were spaced the same distance apart except that in some plantings the cottonwood rows were often 1 or 2 feet further apart. In a few of the older belts the spacing was variable, ranging from 3 to 8 feet. Within the row itself, the trees were planted 4 to 8 feet apart, usually 6, and shrubs from 2 to 4 feet. In some older belts, the spacing in the rows was narrowed by reinforcement plantings, usually of a species different from that first used.

The adopted spacing between rows favoured early closure of crowns and the formation of true forest conditions. In many belts from 5 to 10 years of age, crown closure of the faster growing species has occurred and these have shaded out practically all weed and sod growth. Surprisingly, in 19 per cent. of the belts, a leaf mulch has formed. In places this mulch was from a half inch to over an inch thick. The soil in such cases was all that a forest soil should be, a marked contrast to the hard sun-baked soils of adjacent fields and pastures.

In belts less than 5 or 6 rows wide forest conditions were never found. In such belts, most leaves do not fall directly within the plantation and because of inadequate side density are more easily blown out of the belt. Furthermore, without sufficient side protection, the sun reaches well inside the belt, and so heats and bakes the topsoil and burns out the humus.

In exceptionally favourable areas such as those with sandy soils and good rainfall and especially in localities where intertilled crops are grown, good protection was attained with belts less than 5 rows wide. For the greater part of the zone, belts of 5 to 10 rows in width, better 7 to 10, appear safer. They afford a wider choice in species, an opportunity to plan for long life and replacement, and reduced risk from insects, diseases, rodents, or adverse climatic or soil conditions. Furthermore, in such belts there is more mutual protection and opportunity for the maintenance of true forest conditions.

A controversy has arisen as to the best spacing between rows, with respect both to the use of farm machinery in cultivating the belts and to the silvical requirements of the trees themselves. Considering all factors and giving special consideration to opinion of farmers, there seems no reason under prevailing conditions for adopting spacing any wider than 10 or 12 feet between rows. This appears satisfactory throughout most of the shelterbelt zone. Not a single farmer interviewed desired a spacing wider than 14 feet.

Some individuals, mostly non-foresters, are promoting very wide spacing between rows, in some cases up to 24 to 30 feet. Such spacing, they assert, will take the ordinary machinery and equipment used in large-scale farming. But, with spacing so wide, trees and shrubs have practically no chance of ever developing a closed canopy, and on drier upland sites probably could not survive grass and weed competition unless closely cultivated throughout their entire life. Data taken in the survey indicated that most farmers do not have the time or inclination to cultivate their trees longer than 5 or 6 years. A serious question then arises as to the purposes of planting trees with such spacing; they cannot greatly influence wind and they can furnish only limited protection to soil and crops. Where wide spacing is deemed necessary to fit an individual case, it is felt that no attempt should be made to establish belts, but rather single rows of trees.

Rating of the Shelterbelts.

In the survey, shelterbelts were rated solely on the degree to which they fulfilled their major purpose, that of providing protection against the wind, without regard to other objectives. In making the rating, consideration was given to the survival, growth rate, and vigour of the trees, to the degree of continuity of the belt as a whole and that of the individual rows, and to the prospects that the belt would develop so as to carry out the purposes for which it was established. In assigning a rating value, great emphasis was placed on continuity because gaps due to heavy mortality in sections of the belt reduce markedly its effectiveness as a barrier against the wind.

Belts were rated as excellent, good, fair, poor, very poor, or destroyed.

Excellent belts were continuous throughout their entire length, and had satisfactory survival in practically all rows, a rather uniform height, and better than average growth. Survival in most rows was 80 per cent. or more.

Good belts had fair continuity with not over 2 or 3 small gaps due to mortality or very poor growth per half mile of planting, the aggregate length of these gaps not exceeding 100 yards and with no individual gap greater than 100 feet in length. A typical 10-row belt might have 1 or 2 rows more or less a failure but the other rows highly successful; or 1 or 2 individual rows with fairly large failed places from 100 to 300 feet long; or 1 or 2 rows with scattered trees throughout their length having a total survival for the row of less than 40 per cent. The plantation as a whole had a general survival between 60 and 80 per cent. in most rows, was making satisfactory growth, and gave every prospect of making or had already become an effective shelterbelt throughout its entire length.

Fair belts had 1 or 2 large gaps of 100 to 300 feet or more per half mile of belt; or they had a low survival (usually less than 40 per cent. in 3 or 4 out of 10 rows, in such a survival pattern as to create large gaps in individual rows and so to impair materially the value of the planting as a shelterbelt. Survival in the remaining rows was satisfactory. Average survival of such belts as a whole ranged between 40 and 60 per cent. Growth rate was often below average. Partial failure of certain species or complete failure in the gaps was mostly associatd with patches of unfavourable soil, and to some extent with inadequate cultivation. These plantings with some care will continue to develop but generally cannot hope to perform real shelterbelt functions.

Poor belts were the near failures. They had partial or complete failure (under 40 per cent. survival) in 5 to 7 out of 10 rows, particularly in the tall and intermediate species which were intended to form the shelterbelt's backbone; had 3 or more large gaps of 200 to 500 feet per half-mile of belt; had generally poor growth; and, for the belt as a whole, had a scattered patchy survival of 20 to 40 per cent and dense weeds. Belts that fell into this class were chiefly those given little cultivation in early years. These plantings have little prospect of ever developing into effective shelterbelts.

Very poor belts were complete failures and an eyesore on the landscape. Their condition was mostly due to lack of culitvation. They were invariably full of weeds and contained a scattering of poor, slow-growing trees and shrubs having an over-all survival of less than 20 per cent. Even with care and attention they have no prospect of ever developing into successful shelterbelts.

Destroyed belts were those which had completely disappeared. They had been plowed out for crops or airfields, taken out by changing highway location, drowned out by reservoir construction, burned and grazed out of existence, destroyed by cyclones, or otherwise ruined. Every belt so classified, however, was definitely located on the ground by original individual maps and records which showed the exact location of each belt and date of establishment.

TABLE 1.—CONDITION OF SHELTERBELTS PLANTED IN THE GREAT PLAINS FROM 1935 TO 1939 BY STATES

State	Percentage of belts by rating class in 1944						
	Excellent	Good	Fair	Poor	Very poor	Destroyed	Total
North Dakota	54.2	20.3	14.1	6.6	0.5	4.3	100.0
South Dakota	36.1	28.3	19.0	9.7	5.4	1.5	100.0
Nebraska	62.3	20.8	10.1	4.8	2.0	0	100.0
Kansas	74.3	15.7	4.8	4.8	0	0.4	100.0
Oklahoma	59.7	17.8	7.7	9.3	1.6	3.9	100.0
Texas	64.2	17.9	11.9	4.5	1.5	0	100.0
Weighted average	58.1	20.3	11.2	6.6	1.8	2.0	100.0

The over-all picture of the condition of shelterbelts by states is given in Table 1. For the zone as a whole 78.4 per cent of the belts are rated as good or better, 11.2 per cent as fair, and 10.4 per cent as definitely unsatisfactory. Considering the area over which the plantings were done, the difficulties and handicaps which had to be overcome, that planting was done in a drought period (during the first half of the planting period precipitation was only 50 per cent of normal), and that experts said it could not be done, the showing is most remarkable.

By states the percentage of belts classed as "fair and better" is as follows: Kansas, 94.8 per cent; Texas, 94.0 per cent; Nebraska, 93.2 per cent; North Dakota, 88.6 per cent; Oklahoma, 85.2 per cent; and South Dkota, 83.4 per cent. If only excellent and good belts are considered the percentage by states is as follows: Kansas, 90.0 per cent; Nebraska, 83.1 per cent; Texas, 82.1 per cent; Oklahoma, 77.5 per cent; North Dakota, 74.5 per cent; and South Dakota, 64.4 per cent.

Many factors are responsible for differences in the quality of belts. Usually the belts were best in growth and survival in areas of better rainfall, where soils were friable and sandy, and consequently more favorable, where the farm economy included the growing of intertilled crops, and where there was a relatively high per cent of owner-operated farms. In general, row-crop farmers usually take better care of their belts than wheat farmers in large part because they have equipment well adapted to cultivating shelterbelts and more "know-how" on the handling of row crops. Furthermore, those who practise diversified cropping are generally among

the more progressive and ambitious farmers who do a good job on anything to which they turn their hand, whether livestock management, crop rotation, or shelterbelt cultivation. For the most part, though not always, farmers who own and operate their own farms took better care of their belts than did tenants.

When counties are grouped into areas of comparable characteristics, a marked difference in the quality of belts from area to area is revealed, as shown in Table, 2 opposite. A few of the county groups have an unduly high percentage of Class 4 and 5 belts. Here the development of satisfactory belts appears to constitute a real problem. If the belts are to succeed, a major program of rehabilitation and intensified cultivation is required. Possibly no further planting should be done in such areas until the causes for failure have been overcome.

In the various county groups a very distinct difference was noted in growth rate as one proceeded westward into zones of lower rainfall or passed into areas of less favorable sites. In Nebraska, Siberian or Chinese elm* in 6-year-old belts averaged 17 feet in height in Polk County, 13 feet in Howard County, and 11 feet in Custer County. The average annual precipitation for the areas compared is 26, 24, and 22 inches per annum respectively. In comparable belts, cottonwood in the Red River Valley averaged about 24 feet on the favourable Fargo and Bearden soils, while only 20 to 30 miles to the west on the upland Barnes soils it averaged only 18 feet in height.

Some species, such as Plains cottonwood, honeylocust, and Siberian elm, when grown on comparable sites, showed a progressively greater height from north to south. Others, particularly green ash, American elm, and American wild plum, showed just as good a growth rate in the Dakotas as in Oklahoma or Texas.

Survival and Growth Rate of Individual Species.

Survival and growth rate of 44 individual species are given in Table page 380. The species are grouped as tall and intermediate deciduous trees, conifers, and shrubs, and in each group they are arranged in order of decreasing annual height growth. The table omits about 100 rows where data by individual rows were classified only by genera, and data for 11 minor species; peach leaf willow (*Salix amygdaloides*), mimosa, white spruce (*Picea glauca*), Tatarian maple (*Acer*) *tataricum*). privet, smooth sumac (*Rhus glabra*), sand or chickasaw plum, spirea, currant, peach, and American elder (*Sambucus canadensis*).

These 11 species occupied a total of only 13 rows. The weighted average survival of all species, trees and shrubs combined, in 8,534 rows n the 1,079 belts examined at the average age of 6.4 years was 67.5 per cent. The average height was 10.5 feet and the spread of crown was 6.5 feet.

The survivals given are, in so far as possible, for the original planting only. Wherever possible, survivals were recorded separately for the original planting and for the replanting, which may have been done from 1 to 4 or 5 times in the same row, with different species, and with different spacing. In some cases, however, the data include both the original trees and the replants. This was necessary as records available for an individual belt were inadequate to make the separation, or it was impossible to make a clear-cut differentiation in the field between original and replanted trees. The latter was especially true in older belts where failed spots were small and scattered and had been replanted promptly with the same species. In such cases, survival percentages were based on the present degree of stocking, including both originals and replants. In a few cases, data on survival are included for a single species, although when planted two or more species had been intermingled in a single row. Occasionally where bird food or beauty was a prime consideration, the end of a row (perhaps 100 or more feet) was planted with a species different from the rest of the row. In such cases, the major species only was considered. Survival data thus are slightly more liberal than they would have been on a narrowly considered tally, but again the deliberate by-passing of many successful belts more than offsets this and undoubtedly makes the figures conservative.

Survival for the 17 tall and intermediate deciduous trees ranged from 86.7 to 46.9 per cent and averaged 69.3 per cent. Total heights ranged from 19.1 feet at 6.6 years for Plains cottonwood to 3.9 feet at 5.1 years for bur oak. Average height growth per year ranged from 2.9 to 0.8 feet. The most rapid growth rate found in any belt was in 7-year-old cottonwood near Vernon, Texas Here trees were 50 feet high and averaged 7.14 feet per year. In this same belt the annual height growth of Siberian elm averaged 4.7 feet and of catalpa 3.6 feet.

There was a wide range in the average crown spread for the various species. As one of the chief goals of cultivation is to keep weeds down until the belt has developed a tight crown closure between rows, spread has considerable significance because in large measure it determines, the

*The correct common name for *Ulmus pumila* is Siberian elm. However, the name Chinese elm has come to be widely used throughout the Plains region and is also commonly used in the nursery trade. It should not be confused with *Ulmus parvifolia*, the correct common name of which is Chinese elm.

TABLE 2.—RATING OF EXISTING SHELTERBELTS BY STATES AND BY COUNTY GROUPS WITH SIMILAR RAINFALL AND SOIL CONDITIONS.

State and area	Counties	Average annual rainfall	Site[1]	No. of belts	Distribution of belts by rating classes[2] 1	2	3	4	5	1+2
		Inches			Per cent					
North Dakota										
Red River Valley	Walsh, Grand Forks, Cass	20–22	A	62	81	11	6	2	0	92
Devils Lake	Benson, Ramsey, Nelson	16–20	C	46	26	33	30	11	0	59
Valley City	Barnes, Stutsman, La Moure, Ransom, Sargent, Dickey	16–20	B	77	54	23	12	8	3	77
Towner	Bottineau, Ward, McHenry, Pierce	14–16	B	18	55	17	17	11	0	72
South Dakota										
Aberdeen	Brown	18–20	B	50	16	50	16	12	6	66
Huron	Beadle, Spink	20–22	C	25	20	28	24	16	12	48
Watertown	Day, Coddington, Hamlin, Brookings	21–23	B	40	53	28	13	3	3	81
Madison	Miner, Lake, Moody, McCook	22–24	A	16	75	13	12	0	0	88
Mitchell—Yankton	Sanborn, Davison, Hutchinson, Bon Homme, Yankton	22–24	C	62	37	18	24	15	6	55
Nebraska										
Neligh	Knox, Antelope, Boone, Nance	24–26	B	61	61	25	8	3	3	86
Norfolk	Cedar, Pierce, Wayne, Madison, Stanton, Platte	26–28	A	21	81	5	5	5	4	86
Broken Bow—Kearney	Custer, Buffalo	24–26	B	27	52	15	18	11	4	67
Grand Island—St. Paul	Sherman, Howard, Hall	24–26	B	34	59	15	23	3	0	74
York	Merrick, Polk, Butler, Hamilton, York, Seward, Lancaster	26–30	A	47	68	24	4	4	0	92
Minden—Franklin	Kearney, Franklin, Webster	24–26	B	4	50	50	0	0	0	100
Kansas										
Beloit	Jewell, Mitchell, Lincoln, Ellsworth	24–26	B	28	68	25	7	0	0	93
Salina—Hutchinson	Dickinson, Ottawa, Saline, McPherson, Harvey, Summer, Reno	26–30	A	78	80	10	4	6	0	90
St. John—Pratt	Rice, Stafford, Pratt	24–26	A	69	75	16	6	3	0	91
Medicine Lodge	Comanche, Barber, Kingman, Harper	24–28	B	73	71	18	4	7	0	89
Oklahoma										
Woodward—Cheyenne	Woodward, Ellis, Roger Mills	22–26	C	29	62	17	11	10	0	79
Anadarko	Canadian, Caddo	30–32	B	17	76	12	6	6	0	88
Mangum	Beckham, Greer, Kiowa, Jackson	26–30	B	78	59	20	8	10	3	79
Texas										
Shamrock—Wellington	Wheeler, Callingsworth	24–36	B	91	48	21	21	5	5	69
Childress—Paducah	Childress, Cottle	22–24	B	14	71	29	0	0	0	110
Vernon—Crowell	Wilbarger, Foard	26–28	B	34	70	12	12	6	0	82

[1]Site A, favorable for trees. Site B, mostly favorable for trees. Site C, moderately difficult for trees.

[2]Class 1, excellent; survival mostly 81—100 per cent, Class 2, good; survival mostly 61—80 per cent. Class 3, fair; survival mostly 41—60 per cent., Class 4, poor; survival mostly 21—40 per cent. Class, 5 very poor; survival under 20 per cent.

TABLE 3.—SURVIVAL AND GROWTH OF TALL AND INTERMEDIATE DECIDUOUS TREES, CONIFERS, AND SHRUBS IN THE SHELTERBELT ZONE.

Species	No. of rows	Average age	Average survival		—Height growth— Total	Average per year	—Spread of area— Total	Average per year
		Years	*Per cent*	*Rank*	*Feet*	*Feet*	*Feet*	*Feet*
—Tall and intermediate deciduous trees—								
Plains cottonwood (*Populus sargentii* Dode)	1,402	6.6	59.4	14	19.1	2.9	9.0	1.4
Sycamore (*Platanus accidentalis* L.)	13	4.7	75.4	7	13.2	2.8	8.2	1.7
Ailanthus (*Ailanthus altissima* Swingle)	8	4.2	81.9	3	10.4	2.4	6.1	1.4
White willow (*Salix alba* L.)	6	6.7	86.7	1	16.2	2.4	9.5	1.9
Black locust (*Robinia pseudoacacia* L.)	110	7.0	78.3	5	16.3	2.3	10.6	1.5
Siberian elm (*Ulmus pumila* L.)	942	6.5	70.5	9	14.7	2.3	9.1	1.4
Honeylocust (*Gleditsia triacanthos* L.)	605	7.0	79.0	4	11.5	1.6	7.7	1.1
Northern catalpa (*Catalpa speciosa* Warder)	155	6.6	76.2	6	10.7	1.6	8.5	1.3
Boxelder (*Acer negundo* L.)	159	5.4	85.0	2	8.5	1.6	6.2	1.2
American elm (*Ulmus americana* L.)	594	6.7	69.1	10	9.6	1.4	5.9	0.9
Apricot (*Prunus armeniaca* L.)	70	5.8	46.9	17	8.4	1.4	6.1	1.0
Hackberry (*Celtis occidentalis* L.)*	407	6.0	67.3	11	7.7	1.3	5.3	0.9
Green ash (*Fraxinus pennsylvanica lanceolata* [*Borkh*] Sarg.)	1,034	6.5	74.8	8	8.3	1.3	5.3	0.8
Black walnut (*Juglans nigra* (L.	148	5.9	65.9	13	6.2	1.0	5.3	0.9
Gray's botany and Webster's dictionary both give this as (*Gymno cladus dioica* [L] Koch)	26	6.2	66.2	12	6.0	1.0	3.8	0.6
Western soapberry (*Sapindus drummondii* H. & A.)	13	8.3	51.2	16	7.1	0.8	4.8	0.6
Bur oak (Quercus *macrocarpa* Michx.)	27	5.1	57.9	15	3.9	0.8	2.2	0.4
Weighted average for tall and intermediate deciduous species		6.2	69.3		12.6	1.9	7.4	1.1
Conifers								
Loblolly pine (*Pinus taeda* .)	4	4.8	40.0	8	12.0	2.5	7.0	1.5
Shortleaf pine (*Pinus echinata* Mill.)	9	8.2	29.4	11	12.4	1.5	6.3	0.8
Jack pine (*Pinus banksiana* Lamb.)	2	6.5	85.0	2	6.5	1.0	5.0	0.8
Eastern redcedar (*Juniperus virginiana* L.)	169	5.6	71.8	3	5.2	0.9	3.7	0.7
Blue spruce (*Picea pungens* Engelm.)	11	6.7	37.2	10	5.8	0.9	1.2	0.3
Rocky Mountain juniper (*Juniperus scopulorum* Sarg.)	213	5.1	67.0	5	3.6	0.7	2.6	0.5
Scotch pine (*Pinus sylvestris* L.)	1	6.0	70.0	4	4.0	0.7	3.0	0.5
Austrian pine (*Pinus nigra austriaca* Schneid.)	27	6.4	44.1	6	4.3	0.7	2.5	0.4
Ponderosa pine (*Pinus ponderosa scopulorum* Engl.)	267	5.4	39.2	9	3.2	0.6	1.9	0.4
Ashe juniper (*Juniperus ashei Bucholz*)	1	10.0	90.0	1	5.0	0.5	3.0	0.3
Western white spruce (*Picea glauca albertiana* [S. Brown] Sarg.)	8	5.1	43.8	7	1.6	0.3	1.2	0.2
Weighted average for coniferous species		6.3	55.4		4.0	0.7	2.7	0.5
Shrubs								
Golden willow (*Salix alba vetellina* Stokes.)	14	6·9	71.8	5	12.6	1.8	9.8	1.4
Tamarix (*Tamarix gallica* L.)	43	5.8	66.5	9	8.8	1.5	6.0	1.0
Red mulberry (*Morus rubra* L.)	404	6.2	70.7	6	8.9	1.4	7.2	1.2
Desertwillow (*Chilopsis linearis* [Cav.] Sweet.)	129	6.7	63.3	10	9.0	1.3	7.0	1.0
Russian-olive (*Eleagnus angustifolia* L.)	434	5.5	58.7	13	7.3	1.3	5.6	1.0
Osage-orange (*Maclura pomifera* [Raf.] Schneid.)	348	7.1	67.6	7	8.4	1.2	6.4	0.9
Eastern redbud (*Cercis canadensis* L.)	6	7.3	53.3	16	7.5	1.0	5.6	0.8
American plum (*Prunus americana* Marsh	203	6.0	72.5	4	5.8	1.0	4.6	0.8
Silver buffaloberry (*Shepherdia argentea* [Pursh] Nutt.)	2	7.0	55.0	15	6.0	0.9	4.0	0.7
Common chokecherry (*Prunus virginiana* L.)	67	6.4	67.3	8	5.8	0.9	5.2	0.8
Tatarian honeysuckle (*Lonicera tatrica* L.)	37	5.5	79.2	1	4.8	0.9	3.8	0.7
Sand plum (*Prunus angustifolia watsoni* Waugh)	4	8.0	75.0	2	6.0	0.7	6.2	0.8
Dahurian buckthorn (*Rhamnus dahurica* Pall.)	4	7.2	56.2	14	5.0	0.7	3.8	0.5
Skunkbush (*Rhus trilobata* Nuttall)	14	5.3	59.6	11	3.2	0.6	6.0	1.1
Caragana (*Caragana arborescens* Lam.)	215	7.4	73.2	3	4.0	0.5	2.5	0.3
Lilac (*Syringa vulgaris* L.)	61	6.6	59.6	12	3.4	0.5	2.6	0.4
Weighted average for shrub species		6.6	67.0		7.2	1.1	5.6	0.9

* Includes also some *Celtis reticulata*.

number of years during which cultivation is required. Thus with a 10-foot row spacing, the species with the more rapid rate of spread would attain complete closure in about 6 years, while some important but slower growing species would not close much before 10 or 12 years. Also, most species in this latter group are relatively intolerant and do not cast heavy shade. As the time required to attain stand closure is greater for wide than for narrow spacing by about one year for each additional foot of space between rows, wider space belts should use species with a rapid rate of spread.

The showing of a few species that were not planted extensively suggests the possibility of their wider use. For instance, on the basis of only a few rows, the white willow was superior to Plains cottonwood in survival and in freedom from pests. Its appearance augurs well for its use along with cottonwood or as a substitute for it on some of the deep sandy soils and subirrigated areas where the water table lies at 4 to 8 feet, or on heavier soils with good moisture relations such as the eastern Dakotas and particularly in the Red River Valley. The American sycamore, on the basis of an inadequate trial, may have somewhat the same potentialities in Oklahoma and Texas and possibly even further north. Boxelder was an outstanding species as regards survival, growth, and ability to form a closed canopy and leaf mulch, and could well be used more freely in the northern and central Great Plains. That it was not more widely used in the shelterbelt program appears strange.

The best hardwoods for wide-scale use besides boxelder are green ash, American elm, hackberry, black locust, Siberian elm, honeylocust, and catalpa. Black walnut and Kentucky coffeetree do well on moderately friable soils of good fertility and moisture relations, but their value is questionable because of their heavy branching and relatively open crowns. Apricot sustained considerable frost damage toward the northern end of its planted range and apparently should be limited largely to Texas, Oklahoma, and the southern third of Kansas unless more frost-hardy varieties can be developed. Ailanthus and western soapberry are low-value trees and, because of their tendency to sucker profusely, are rather objectionable. But oak is an extremely drought-hardy species and warrants wider use, provided rabbit damage can be held in reasonable limits. Mimosa and catalpa deserve wider trial in the south.

Survival of the 11 species of conifers planted in the shelterbelt project ranged from 90.0 to 29.4 per cent and averaged 55.4 per cent. Height growth ranged from 2.5 to 0.3 feet per year. The lateral rate of spread is only about one-third to one-half as great for conifers as for deciduous trees and shrubs, and hence a considerably longer period of cultivation is needed to keep them reasonably free of weeds. Also, their slow growth rate increases the chances of suppression and "whipping" by the faster growing trees and shrubs in adjoining rows. Loblolly pine and shortleaf pine in Oklahoma and Texas had a surprisingly good growth rate but survival was mediocre. These two pines are promising enough to warrant further trial from southern Kansas southward to Texas on well-drained, deep, moderately sandy soils free of surface carbonates and of alkali.

Considering survival, growth, and adaptation to a wide variety of conditions, the eastern red cedar and Rocky Mountain juniper are by far the outstanding conifers in the Plains region. Both species, the latter particularly, have proved themselves well adapted to a wide range of soil textures and climatic conditions and are generally free from pests and damages. They are in fact the only conifers that have had uniformly high survival under a wide variety of conditions. In many belts scattered throughout the whole shelterbelt zone they have attained virtually a 100 per cent survival even at 6 and 7 years of age. Earlier planted trees scattered throughout the region also attest their hardiness and long life. Ashe juniper was found in only one belt and was doing well. Reportedly somewhat immune to cedar-apple rust, it may have a wider use. Growth of junipers is rapid, they withstand the competition of grasses and weeds, they are persistent, and mature trees give excellent winter protection. Growth and survival markedly reflect the degree of cultivation.

Jack pine and Scotch pine have done well but were found only on a few favourable planting sites. They prosper only on well-drained sandy soils free of alkali and carbonates. Austrian pine and Rocky Mountain ponderosa pine had mediocre survival and rather slow growth rate. Ponderosa was satisfactory in survival only in Nebraska and the northern two-thirds of Kansas, and Austrian pine was moderately successful from Nebraska to Oklahoma. Both pines prefer well-drained upland soils ranging from loamy sands to friable silt loams free from an excess of alkali or carbonates.

In some areas under favourable soil and climatic conditions, the slow-growing spruces did fairly well, but in most cases they have attained only mediocre success. They apparently do best on sandy-loam to silt-loam soils and appear to require much more care and attention than most species to prevent heavy losses by drought, heat, or competition with weeds. Because of their high aesthetic value they are probably worth planting on a limited scale in the Dakotas and Nebraska, but only in cases where special care can be given them.

The term "shrub" is used rather loosely in Table 3 because occasionally such "shrubs" as osage-orange and red mulberry were used in the interior of the belt as intermediate or small trees. Generally, however, shrubs were used in the outside row of the belt or in the row next to it in order to provide a tight wind barrier close to the ground. In some belts, usually near a road, the end of the shrub row of such a species as Russian-olive would be finished out with an other species in order to provide contrast in foliage or beauty.

Shrub survivals range from 79.2 to 53.3 per cent and average 67.0 per cent. Total heights range from 12.6 to 3.2 feet and average from 1.8 to 0.5 feet per year. The rate of spread was 0.7 to 1.0 feet per year for most species. Considering the position of the shrub rows on the outside of the belt and the beating they take from weeds, wind, sun, livestock, and sometimes from farm machinery, survivals are highly satisfactory. Practically all the shrubs listed will grow well on a large variety of soils. All have high aesthetic value. A few species are rather limited as to the type of sites on which they can be planted successfully. Golden willow in the Dakotas and redbud in Kansas, Oklahoma, and Texas do best only on the more favourable sites with good moisture relations. The other species rate rather high in ability to withstand drought. The success of the eastern redbud, one of the most beautiful of all the shrubs used in the project, warrants its more extensive use on favourable sites from Nebraska southward.

Considering survival, growth, adaptability, and all-around value, probably the outstanding shrubs are Russian-olive, wild plum, common chokeberry, tatarian honeysuckle, red mulberry, and lilac. Mulberry appeared to freeze back rather badly north of central Nebraska, and desertwillow north of the Oklahoma-Kansas state boundary. Osage-orange also suffered from freezing north of the Kansas-Nebraska line. Russian-olive had considerable frost injury in North Dakota. It would appear desirable not to plant these species extensively north of the various lines indicated. In areas where hailstorms are frequent, mulberry often is badly injured, but the damage is usually temporary.

Only a few rows of silver buffaloberry were seen in the Dakotas. As the buffaloberry apparently suffered no injury while the Russian-olive in the same belt was severely frozen back, possibly it can be used as a substitute for the latter in the north. Caragana, or Siberian pea tree, had good survival, but its very low growth rate and its high susceptibility to defoliation by blister beetles and grasshoppers warrant limiting its use and giving preference to other species.

Lilac has done better than earlier reports would lead one to expect. It is especially effective along roads and highways and near buildings because of its high aesthetic value both in leaf and in flower. In the north it shows itself to be a rather tough hardy shrub, with its slow growth rate as its chief disadvantage. It appears to require fertile soil and intensive cultivation for satisfactory growth.

American plum and common chokecherry generally had good survival, withstood drought well, and are highly prized for their fruit, which is used extensively in making jams and preserves. Some of the fruit was even being marketed in local stores.

Everything considered, survivals for most of the 44 species listed are eminently satisfactory. In fact, these survivals compare favourably with attainments in many plantings in forested regions. Failures in these belts, however, appear to have been magnified out of all proportion by foresters and others while the successes have not been generally recognized In large part this is due to the fact that the shelterbelt planting program was carried out under a pitiless national and local spotlight and became in part a political football. Unlike some forest plantings in remote areas where failures of several hundred or a thousand acres attract little or no attention or comment from foresters, this venture was under close surveillance from the very beginning. Furthermore, each belt was under local public scrutiny. Indeed, farmers were discovered who had checked not only on their own belts, but on those of their neighbours, and who had also personally checked the survival of individual rows in their own belts and could quote exact survival percents by years.

Although survival was generally satisfactory, it was extremely variable for some species and sometimes consistently low under certain conditions. Some of the failures must of course be attributed to the severity of the local climate, which is all the opponents of the project made it out to be. Planted in a period of unusually severe drought, the trees went through the hottest season of record as well as the coldest. Despite every obstacle, the trees did grow and are succeeding.

Strangely enough, the Plains cottonwood is a problem species. It does best on deep, friable, sandy soils with a high infiltration rate, deep storage of rainfall, and moderate water-holding capacity. On heavy upland soils, such as loams to clays, particularly in the areas of lighter rainfall it grows slowly and passes out early, sometimes within 3 or 4 years after planting. It does poorly on very coarse sands or gravels, as such soils have inadequate water-holding capacity despite high infiltration.

A striking contrast in survival and height of cottonwood, and of other species as well, may be seen within the same belt where there is considerable variation in soil texture. Cottonwood of excellent form and with a survival of from 70 to 95 per cent may be found on a sandy area but of poor form and survival of from 0 to 20 per cent on land only 50 yards away with a tight subsoil. On the latter area height may be only 50 to 70 per cent of the average. These variations in height of the tallest trees often give the belts a wavy or undulating appearance in silhouette.

Cottonwood is subject to considerable damage and mortality by Cytospora canker, Texas root rot, wetwood wilt disease, and perhaps also by leaf rust, freezing, and borers. There have been heavy losses in the north-eastern portion of South Dakota and in the Big Bend section of Kansas on sites which otherwise appear highly desirable for cottonwood. It is also reported to suffer from competition when grown next to Siberian elm, as the latter is supposed to be a voracious feeder for surface moisture. Such competition appears most severe in the drier parts of the zone or on heavier soils which retain much rainfall in the top 2 or 3 feet of soil.

Ponderosa pine is also a problem, especially in the Dakotas. It is a highly desirable tree because of its long life and fairly dense crown. Once established, it is very drought hardy, but the low survival in early years shows that the technique of getting it off to a good start has not yet been adequately developed. Judgment would indicate that methods of nursery practice which result in thin fibrous roots and a stumpy tap root must be overhauled, since survivals of 30 per cent or less show that the young tree does not stand the shock of field planting any too well. It may be that transplanting in pots or in balls of earth is the answer to higher initial survival. In any event, care should be used in recommending this species.

The data indicate the desirability of a drastic reduction in cottonwood planting, limiting the species largely if not exclusively to deep sands and loamy sand soils, or sites with permanent water tables at 4 to 8 feet. On upland loams it appears safest not to use more than one row in a 5-row to 10-row belt and to plant it only at the eastern edge of the shelterbelt zone where rainfall is somewhat higher and where losses have been negligible in existing belts. If the wetwood wilt disease spreads, even less cottonwood may be desirable. Site requirements of cottonwood are more rigid in Oklahoma and Texas than they are in the Dakotas, because in the latter the unfavourable effect of compact upland soils is counterbalanced by the tendency of snow to lodge in the belts and to bring about a greater recharge of deeply stored moisture than would occur further south in the absence of snow.

Siberian elm, incorrectly known as Chinese elm, is a remarkable shelterbelt tree. It forms a dense shade, thus aiding greatly in keeping down weeds; it is fairly tolerant and retains live branches almost to the ground; the twigs and branches are rather finely divided and so intertwine as to form a dense windbreak at all times; occasional failures in the rows are filled in rapidly; both height growth and survival are good. It has been frowned upon in some quarters because it is subject to wind breakage and to wood-rotting fungi when broken or cracked open.

Siberian elm is also subject to frost damage. In the great freeze of November 11, 1940, a considerable number of elms were killed. In Nebraska and Kansas especially, it seems to have recovered by sprouting from adventitious shoots and to some extent also from the roots. In many situations the sharp freezes of September 1942 killed the elm back to the main branches or stem, but it has generally recovered well. Throughout the shelterbelt area, few belts had more than 5 per cent of the trees, few belts killed by the cold although many gave evidence of top-killing for from 3 to 5 feet. Many of those which probably appeared dead shortly after the severe cold snaps have resprouted, bushed out, closed up the rows, and made enough height growth to overtake the more cold-resistant native trees such as green ash, American elm, and hackberry in adjoining rows.

Some of the poor sandy soils, especially those whose topsoil has been blown away, are very deficient in nutrients, especially nitrogen. Here growth is poor, the foliage is yellow, and the plants do not look healthy and strong. The species making the best growth on such soils were Plains cottonwood, black locust, red mulberry, Siberian elm, and desertwillow. Species whose growth is strongly retarded include honeylocust, osage-orange, green ash, hackberry, and black walnut. The foliage of honeylocust especially becomes a pale yellow-green on such sites. These 5 species should not be selected for extremely sandy soils.

Problems Appearing in the Belts.

Adequate cultivation is the most important single factor in determining success or failure of tree planting in the Plains. This was fully recognized by those involved in the Prairie States Forestry Project. They insisted upon good cultivation of all the belts established with federal aid. Belts that had good care usually survived very well; those that received poor cultivation showed low survival and poor growth. The striking relation between quality

of cultivation and the success attained by the shelterbelts is brought out in Table 4, which is based on 293 belts for which definite cultivation history was available.

Considering the area as a whole, farmers have done a remarkably good job of cultivating their shelterbelts. Many belts from 5 to 10 years of age have crown closure and require no further cultivation of the interior rows. In the last few years, however, cultivation of many belts has been poor or even lacking entirely. Thus, only 56 per cent of the plantings 2, 3, and 4 years old were getting satisfactory cultivation in 1944. This deficiency in recent cultivation is caused by difficulties growing out of the war such as a shortage of manpower, few machinery replacements, and insufficient gas. In some cases, a minority, it is undoubtedly due also to lack of a sustained interest in the planting by the owner or tenant. This letdown in large part has grown out of the lack of an adequate, organized follow-up action by foresters when the project was terminated. This failure again is due to the war.

Many farmers have done an outstanding job in cultivating their belts and are extremely proud of them. For instance, Mr. Al Mattson of Oakes, North Dakota, who farms 640 acres of land, managed to cultivate the 9 lineal miles of shelterbelt on his property several times in 1944 in spite of the fact that he had to do virtually all his farming single-handed, having only a 9-year-old boy to help him out on a part-time basis in the summer. The Mattsons remarked that while some of the neighbouring fields were "blowing" due to wind erosion, their own fields, protected by 1937 plantings, were well stabilized. Mrs. Mattson was perhaps even more enthusiastic about the belts because she no longer scooped a bushel or more of soil out of her house following each windstorm.

Good farmers had good belts. Where one found a neat, well-kept set of farm buildings and fields clean of weeds, one invariably found well-tended shelterbelts. *Vice versa,* where the farmstead was run down and rusty farm machinery and equipment were scattered around, one more often than not found the trees given rather poor care. After some experience it was possible to guess rather closely what one would find in the belts by a quick look at the farm buildings.

TABLE 4.—RELATION OF CULTIVATION HISTORY TO RATING CLASS OF SHELTERBELTS

Degree of cultivation	Number of belts	Per cent of belts by rating class[1] 1	2	3	4	5	1+2
Excellent ..	.. 43	95	5	0	0	0	100
Good ..	.. 86	77	23	0	0	0	100
Fair ..	.. 86	67	20	6	7	0	87
Poor ..	.. 78	60	13	18	8	1	73

[1]See footnote to Table 2 for definition of rating classes.

These results lead to the conclusion that in action programs such as fostering tree planting on farms, the class of co-operator selected is a primary consideration. However, as in other conservation programs, limiting work to the master farmer type results in by-passing those most in need of assistance. Far too often, those who require most help and guidance are located on the sandier and less fertile soils which are most subject to extensive and serious wind erosion. Mismanagement of these farms may threaten neighbors doing a good job of farming and may cause damage and create difficulties for others miles away.

A rather serious problem is the tendency for farmers to turn livestock into the belts (Fig. 4, bottom). This is believed to be due to the fact that some farmers come to look on the belts as "waste land," *i.e.,* land not actually producing a revenue. Furthermore, on the Plains, shade in the summer and protection from wind at other times is at a premium; there is some grass and feed in the belt; and the fenced area provides a good holding lot. Besides, are not the trees established? What damage can stock do now? It would appear that the need for exclusion of livestock from shelterbelts must be constantly sold and resold by action and extension agencies stimulating Great Plains tree planting.

Most belts were fenced, or if not entirely enclosed were fenced into the farms. Towards the end, Project foresters in the diversified farm sections fenced the belt out of the farm so that it was open only to the road; and in the wheat sections, where normally cattle graze in the stubble fields, they fenced the belt on all sides against the livestock. In areas of livestock damage, belts so fenced suffered only minor injury.

Where livestock protection is a primary purpose of shelterbelts, much needs to be done to work out both a satisfactory type of belt and satisfactory management. Observations lead us to believe that a belt with fast-growing species such as cottonwood, sycamore, or Siberian elm planted in the first row close to the fence might be satisfactory. This would create a quick shade and yet leave the trees protected from trampling or grazing by the animals in the feed lot or pasture. In other areas the belt might be of unpalatable species and opened to stock piece by

piece rather than all at one time. Such construction would counteract the present temptation to allow livestock in the belts.

Cattle damage by states was as follows: North Dakota, 2.4 per cent; South Dakota, 7.1 per cent; Nebraska, 5.3 per cent; Kansas, 7.2 per cent; Oklahoma, 19.2 per cent; and Texas, 12.1 per cent. For the area as a whole, 8.1 per cent of the belts were damaged by cattle (incluiding horses and mules). Most of this damage is light as yet because the practice had just started, but a few more years of abuse will undoubtedly completely ruin many belts. Damage occurs from browsing, breakage, and trampling. The species preferred in browsing varied somewhat by localities, but those browsed most heavily included wild plum, hackberry, American elm, and boxelder. Moderate damage occurred in cottonwood, Siberian elm, and green ash. Stock damage to osage-orange was negligible. There was practically no browsing on conifers but some damage from trampling. Green ash and the elms were often ridden down by cattle. Besides cattle damage, some injury was caused by hogs and sheep, amounting to 0.7 and 0.9 per cent of all belts respectively. Hogs appear beneficial where Johnson grass is a serious pest. In some places chickens, turkeys, and other farm fowls utilized the belts heavily but apparently caused no damage.

In a limited number of belts, the failure of 2, 3, or 4 contiguous rows of trees in a 10-row belt is creating a serious replacement problem. Filling-in is essential so that the crown canopy may close and a forest condition be attained. The loss of only 1 or 2 rows may not be too serious when the adjoining rows are of species whose crowns will spread rapidly enough to fill in the holes, and are dense enough to shade out the weeds and grass, but under other conditions may be ruinous. The problem of rehabilitating failed rows is more acute in the north than in the south because of slower growth, and more in the west than in the east because of competition. Replacement problems are serious in north-eastern South Dakota and in central Kansas, where heavy losses of cottonwood are occurring. In some places virtually all the cottonwood in as many as 5 rows in some belts have been killed by a combination of factors including freezing, insects, and diseases. This suggests the desirability of using not more than two contiguous rows of the same species in a shelterbelt, so as to distribute the risk among a variety of species, preferably at least 3 to 5 in number, with only one species in any one row. Then the failure of a single species in later years will least impair the effectiveness of the shelterbelt.

In South Dakota the Soil Conservation Service is devoting attention to this problem of replanting. One promising method being tried is to run a heavy disk down the failed rows to fell and break up the 10-to 15-foot half-rotten snags. Replacements are machine planted, using 1 row where two had failed, 2 rows where 3 had failed, and 3 rows where 4 or more had failed. Preference is usually given to such semi-tolerant and rapidly spreading trees as boxelder and Siberian or American elm.

The belts do sap moisture from adjacent fields. Cotton, corn, and kaffir corn appeared to be most affected. Rows immediately adjacent to the belts were materially reduced in height, and fruiting reduced in volume. Fragmentary and not wholly reliable data indicate that the increased production in other rows generally more than makes up for the losses, but it is probable that still greater crop production could be obtained if the tree roots reaching out into the field were severed. Just how this can be done cheaply and simply, and what effect this root disturbance would have on the trees, is unknown.

Rodents have been a perennial problem in connection with shelterbelt establishment. The worst pests were jack rabbits, cottontail rabbits, and mice. Systematic hunting and a judicious program of control carried out in co-operation with the Fish and Wildlife Service during the life of the Project usually kept the damage within reasonable limits, but damage appears now on the increase. Recent rabbit damage was especially serious on American and Siberian elm, hackberry, catalpa, and bur oak. In some individual belts girdling has resulted in heavy loss and often over half the surviving trees were of multiple-stem form, with trees only one-fourth of normal height because of repeated girdling. Mice damage cedars buried under the snow.

Hail damage was noted on 13.8 per cent of all the belts and was heaviest in Kansas. In over 90 per cent of the cases the trees healed completely and made good recovery within two or three years after the storm. Usually the damage was limited to killing of smaller branches. As insurance companies have worked out the areas of greatest hail hazards, it should be possible in such areas to use the more hail-resistant trees. Snow breakage was noted in 2.3 per cent of all belts, confined mostly to the Dakotas and Nebraska.

The worst defoliators observed were blister beetles and grasshoppers on caragana, Cecropia moth larvae on boxelder, tent caterpillar on Siberian elm, webworm on chokecherry, leaf beetle on cottonwood, and bagworm on the junipers. Early shelterbelt reports stress the defoliation of entire belts in the gras hopper invasion. Twig girdlers were observed on boxelder and in the south on honeylocust. Tip-moth larvae were found working in ponderosa pine and Scotch pine in Nebraska. Borers were fairly

common in green ash, black locust, cottonwood, and honeylocust. Aphids were noted, especially on cottonwood, and red spider on the junipers. Generally, the damage caused by insects was not severe and not much mortality is attributed to them as yet. Their worst feature was reducing the vigor of trees or impairing their form. Insect pests will require close watch and may warrant control measures if damage becomes too serious.

Farmers, many farmers, as well as foresters want to know how to manage their belts. But when one does not know in what row treatment can or should begin, or even in what species cutting could be permitted, or how thinning would affect the protective value of the belt or its ability to stop wind erosion or to trap snow, the very thought of being responsible for prescribing treatment gives one cold shivers. Many belts are now in need of silvicultural improvement or rapidly approaching that stage, but for such work there is little precedent or experimental data.

Probably the most general single type of improvement cutting needed, and relatively the simplest, is the removal of multiple sprouts so as to obtain only one good stem. Such sprout cutting is most badly needed in hackberry, American elm, catalpa, and Siberian elm, which as a result of some past injury now have 2 to 7 sprouts from 1/2 to 1 inch in diameter. In some cases catalpa sprouts will produce good fence posts without thinning, but other species give evidence of forming only bushes. But. should such cutting be permitted; and, if so, how heavy should it be? And would such cutting, especially in the narrower belts, adversely affect their protective value; and, if so, would the production of a few straight-stemmed trees be a greater benefit than the damage caused by their removal?

In many belts, particularly in Nebraska and Kansas, fast-growing species, such as Russian-olive, mulberry, or catalpa, often develop wide-spreading branches that overtop and whip the tips of conifers in the adjoining row. How should release be effected; should the offending branches be cut, or the plants pollarded, or cut to the ground ? Or will the damage to conifers be serious in the long run, considering that wind protection is the essential need ?

In a limited number of cases, particularly in Oklahoma and Texas, an overstory of hardwoods is suppressing conifers, usually cedars, which were interplanted with the faster-growing trees in the middle of the belt. Should cutting now be done in the hardwoods which make up the backbone of the belt; and, if so, how big a hole is permissible considering that when a notch is made in the belt wind may funnel through? Or should the conifers be allowed to work along in the hope that should an overstory tree die they would be available to fill in the gap?

In a few instances, cedars were interplanted with willow in a single-row belt. The willow has now spread and forms an excellent windbreak as wide as it is high. The cedar is growing rapidly but it is being badly top-whipped by the willow. What kind of cutting, if any, should be followed?

In some belts species such as black locust, chokecherry, and wild plum have suckered and spread into adjacent rows. They are forming a dense barrier to the wind close to the ground and are providing splendid protection to the main belt. Next to the shrub row is one row and occasionally two rows of conifers. The inadequate stands of conifers, especially pines, need help if they are to overcome both root competition and whipping. Ought there be any release, and, if so, what kind? Should suckers be grubbed out to prevent resprouting with possible damage from soil blowing?

An occasional tree is badly scarred in cultivation or broken or split by snow and wind. Good silviculture would indicate removal of split or cracked stems, or cutting back to the ground. But from the standpoint of shelterbelt maintenance is it better to chance loss of these trees from decay at some future date rather than to break the continuity of the belt with subsequent troubles from openings now?

In most belts, pruning appears neither necessary nor desirable. But in some belts it may be desirable to remove dead or living branches on interior rows to obtain a clean bole up to 6 or 10 feet. Depending upon circumstances, pruning of low-spreading limbs of thorny species like honeylocust, black locust, or osage-orange is highly desirable to permit longer cultivation and to reduce hazards to tractor operation or to animals pulling equipment. The removal of branches close to the ground is generally undesirable because wind can dissipate the leaf fall and dry out the belt, and light will encourage the minor vegetation. The lower twigs and branches even of hardwoods are valuable in the winter in cuting down wind velocities and in conserving moisture.

Belts older than 6 years contain trees 4 to 6 inches in diameter. In such belts the farmer is tempted to do light thinning for posts, fuel or small poles which are otherwise unavailable. In Oklahoma 8-year-old black locust is of fence-post size. In other cases belts contain catalpa, mulberry, osage-orange or black locust sometimes growing in clumps in which cutting one or several stems for posts appears feasible so long as one or two sprouts are left. In some instances

thinning might improve growth of remaining trees without impairing the primary value of the planting as a shelterbelt. But what kind of advice should be given the farmer? In most woodlot stands, it makes comparatively little difference what is cut and where it is located in the stand, but this is not true of a shelterbelt. The man with the axe can ruin a shelterbelt even as he "improves" it or makes an intermediate cutting!

Values and Benefits Derived from the Young Shelterbelts.

The values already derived from the field shelterbelts in the Plains are manifold. In some areas they have completely revamped the appearance of the landscape. In whole townships where the skyline was unbroken except for buildings or an occasional small group of trees, there are now dozens of thrifty, young shelterbelts from 15 to 40 feet high limiting the horizon to only a few miles at most. The combination of shrubs, conifers, and taller growing trees is a definite asset to the appearance of a farming community at any season. They add color and contrast. They dress up the landscape, the farmstead, highways, and roads. They give the community an appearance of permanence—something solidly and deeply rooted in the soil. They dispel some of the fly-by-night aspect which has come to be associated with prairie carpetbaggers who settle down for a few years to gamble on the hope of two good wheat crops in succession and then promptly pick up and depart.

Mr. W. C. Isern of Alden, Kansas, expresses well the philosophy of the solid "permanent" type of farmers in this region. To him, trees are worth while for their own sake. His chief interest is in what mass community effort in tree planting would mean in the beautification of the landscape, in the protection afforded farm homes and barns, and in the general well-being of his particular section of the Arkansas River Valley for the present and coming generation. Whether there is any appreciable gain in the amount of crop produced as a result of shelterbelt protection is of little concern as compared with the social benefits in making his section an attractive place in which to live.

The belts, young as they are, have already had a very measurable effect in reducing wind erosion, especially on sandy lands. Many individual farmers commented on the value of the trees in reducing sand blowing in fields, increasing yields of crops, and especially in protecting orchards and truck crops. This is especially true in Oklahoma and Texas, where belts 8 to 10 years old are 25 to 40 and more feet high—tall enough to cause a marked reduction in wind velocity in a zone several hundred yards wide on the lee side of the belts. In some cases belts and other plantings have been instrumental in reclaiming sandblow areas which were menacing highways and crop land. Cottonwood proved to be the outstanding species in successful stabilization of these menacing sandblows, paving the way for the invasion of grass.

The belts are veritable havens for upland game birds, particularly pheasants and doves, and for numerous insectivorous song birds. Nests of beneficial hawks and owls are common in the trees. In some places deer and squirrels have migrated to the shelterbelts from nearby natural woodlands along streams. One adverse comment on the tree plantings came from a farm housewife in Kansas who reported that coyotes denning in nearby belts were making raids on her turkeys and chickens which roosted in her belt. In the over-all picture of game and wildlife, the belts are enthusiastically endorsed by sportsmen, hunters, and landowners. In one community, pheasant hunting in the shelterbelts was being successfully advertised as the lure to attract Chicago nimrods to the Plains.

Wm. Thompson of Haviland, Kansas, one of the first in Kiowa County to enter into the program, sums this all up as follows: "The value of my tree belt can hardly be estimated. The trees add greatly to the appearance of my home; the protection they have given my livestock during the winter months has been worth an equal amount; they have been of great value in protecting my fields from wind erosion; and last but not least they afford protection for wildlife. We have many game birds now such as pheasants, quail, and doves, and of course many other birds that we never had before."

The plantings have a practical value to the farm women in furnishing a variety of fruits suitable for making jams, preserves, and jellies. The plums and chokecherries bear fairly well at 4 years of age and have heavy crops at 7 or 8 years after planting. Apricot and peach fruit are somewhat later. Black walnut is beginning to bear seed on some of the 7- to 10-year-old belts from Kansas southward and will probably have substantial value in the future as a nut producer.

In the southern portion of the Plains the belts have already furnished some fence posts and small poles for turkey and chicken roosts, and for use in gardens. Greater returns can be expected in the future from such products.

The Project has taught a whole new generation how to plant and care for trees. In hundreds of communities and on thousands of farms there are now people who have themselves

worked on various phases of shelterbelt planting. The knowledge and techniques so acquired will enhance the chance of success of future tree plantings in the area. Despite war difficulties, it has stimulated sales of planting stock for ornamentals and fruit trees handled by commercial nurserymen, and will also directly improve sales of shelterbelt stock as conditions again become more normal.

According to personnel of the Soil Conservation Service, the Forest Service Shelterbelt Project has been directly responsible for the establishment of several new soil conservation districts because of the great interest in tree planting. In some of these districts the farmers regard tree planting as the most important soil-conserving measure to be adopted in their farm program.

Long-Range Outlook on the Great Plains Shelterbelts.

Many shelterbelts should remain effective to the end of the century. As they are generally planted on the more favourable soils and rainfall areas of the Great Plains, it is expected that those belts which received good care when young will reach a height of 40 to 80 feet and remain effective for a period of 30 to 60 years. Based on observations of older plantings made prior to 1900, some will undoubtedly exceed that age. The trees are expected to live longer in the northerly than in the southerly portion of the shelterbelt zone because of the slower growth rate and less rapid depletion of deeply stored subsoil moisture. In the north the belts have the added advantage of trapping snow in drifts from 5 to 10 or more feet deep and so bringing about a considerable increase in soil moisture. This situation does not hold in the southern part of the zone where snowfall is negligible.

Toward the end of their life span, the great majority of the belts will need to be replaced by replanting. A few belts in the eastern edge of the zone where rainfall is higher, or on areas of sandy soil with permanent water tables at 4 to 8 feet below the surface, have some possibility of reproducing naturally from the green ash, boxelder, catalpa, American and Siberian elm, and redcedar in the stand. A number of seedlings of some of these species were found in the older belts. The possibility also exists of getting a second stand from species which sprout readily from stumps, or sucker rather profusely, such as black locust. How to get replacement of the older stands by cultural methods or by planting poses a whole series of problems that the future must solve.

Shelterbelt forestry is a new type of forestry in America. It differs greatly from most forestry in that the emphasis necessarily is upon the maintenance of a wind barrier over a long period of time. Wood products, though just as valuable per acre as in many another forest region, are of secondary value to the protective services these belts provide. A whole new type of silviculture is necessary because the initial planting is but the first step.

Plains forestry therefore is a challenge to American foresters. A few undaunted by the cry of the experts accepted that challenge and the successes attained on miles of belts and thousands of farms under all kinds of conditions attest to the daring, enthusiasm, and technical skill they brought to bear on the difficult problem of establishment. The Prairie States Forestry Project is a living monument to them.

Plains forestry must not be allowed to die out with this effort. The prize is too valuable, the opportunity too great to permit it to be discarded for want of a sponsor. No better way of bringing the forest and the people together ever was developed.

Success has been attained so far, success greater by far than even its enthusiasts dreamed of, and in a period when many farmers believed the Plains were doomed to become a desert. But the successes must not blind us to the fact that forestry in this region has a long, hard row ahead. It is not the relatively simple processes of planting trees where trees grew before, of marking trees for cutting, or of protecting forests from fire. It is not in an area where mistakes are seldom seen and one's technical skill is unquestioned. It is not in an area where one can work constantly in the woods. It is not in a region where things just happen and happen easily with little or no help from foresters. Rather it is in a region which can well try a man's soul—his patience, imagination, technical understanding. It is in a region where failures, probably many failures, will occur; where experts will again say it can't be done; where sun and wind and frost and drought will combine to discourage the faint-hearted. Plains forestry is indeed a challenge.

In some instances the belts were so placed as to provide special protection to feed lots in which cattle are fattened for market. These plantings have a strong appeal for farmers and ranchers because it is well known that cattle make better gains in feed lots protected by shelterbelts, and that they come through the winter better and with less shrinkage when given tree protection against biting winds.

Judging by results of the 1944 survey and opinions of farmers, business men, and agricultural technicians, Plains forestry faces a herculean task. Some of the things it must do include the following:

1. Provide more intensive shelterbelt planting in sandy areas where wind erosion is serious.

2. Determine silvicultural practices which can safely be applied to existing shelterbelts.

3. Stimulate tens of thousands of farmstead plantings.

4. Develop management principles for the care, protection, and renewal of belts as they grow older and tend to open up.

5. Devise management methods for belts and farm woods.

6. Renovate many existing farmstead shelterbelts where failures are threatening to reduce their effectiveness.

7. Improve density and design of belts.

8. Provide trees around rural schools and other community buildings.

9. Extend the planting of living snow fences.

10. Push shelterbelt and tree planting ever westward.

11. Encourage belts for livestock protection both winter and summer.

12. Stimulate the planting of waste lands and woodlots for fence posts.

13. Develop new methods and techniques of planting.

14. Search continuously for new species or desirable new strains.

15. Discover the limitations of tree planting.

16. Foster more community forests and parks.

17. Determine opportunities for wider planting of fruit-producing species such as wild plum, chokecherry, apricot, bird cherry, Dolgo crab, jujube, Ussurian pear, and crab apples.

18. Create a limited number of publicly owned forests and ranges in problem areas.

Summary and Conclusions

The Prairie States Forestry Project, more commonly known as the Shelterbelt Project, was in operation from 1934 to 1943. During that time, nearly 19,000 miles of belts were planted on approximately 33,000 farms. A survey of the plantings made in 1944 covered 1,079 belts, or a random sample of 3.6 per cent of all belts planted.

In terms of meeting the main purpose for which the belts were established, that of protection against wind, the Project was a success. For the area as a whole, 78.4 per cent of the belts were rated as good or better, and only 10.4 per cent as unsatisfactory. Tree survival throughout the entire area covered was generally good. Survival of those species which were planted in more than 100 rows (probably also in more than 100 belts) ranged from 39.2 per cent for ponderosa pine (267 rows), the poorest, to 85.0 per cent for boxelder (159 rows), the best.

There was a direct relation of quality of belts, based on survival and growth, to the annual precipitation and the class of planting sites selected. Growth rate in the areas of better rainfall was 30 to 50 per cent greater than in the more arid part of the shelterbelt zone.

The best planting sites were generally the deep sandy loam or loamy sand soils with deep moisture penetration. There was a striking differential in survival and growth rate in favour of sandy as opposed to heavy soils for many species.

The most striking feature of the belts is their rapid height growth. The belts average about 7 years of age and in North Dakota are 16 feet high, in Nebraska 20 feet, and in Texas 24 feet. In the southern Great Plains a number of belts 7 to 10 years old are 25 to 40 feet high and are already very effective in reducing wind erosion. Growth rate per year is 2.9 feet for cottonwood, 2.3 feet for Siberian elm and black locust, and about 1.3 feet for such slower growing hardwoods as green ash. Conifers such as ponderosa pine and red cedar are making from 0.6 to 0.9 feet per year. Shrubs are growing at an average rate of 1.1 feet per year. The most rapid growth observed was in a 7-year-old Texas shelterbelt which had trees 50 feet high and 10 to 12 inches in diameter.

Most of the belts from 5 to 10 years old have complete stand closure in that part of the belt where the species were fast growing. A forest condition, as evidenced by a leaf mulch from 1/2 to 1 inch deep, is developing in these rows.

Benefits which have already been derived from the program include landscape improvement, control of wind erosion, snow traps along highways, protection of farmsteads, gardens, orchards, and feed lots, providing a haven for game and song birds, furnishing wild fruit for preserves, providing fence posts and small poles for use on the farm, and bringing new districts into the soil conservation program.

The chief problems are inadequate cultivation on half of the belts under 4 years of age (due to shortage of labor) and cattle damage in 8.1 per cent of all belts. Problems of a more or less serious nature involve various insects, disease, and rodent pests, and some damage from hail

and snow breakage. Great need is developing for silvicultural treatments, but no information is available as to how to proceed without reducing the effectiveness of the belts either now or later. Similarly management and replacement methods must be worked out. Research is needed on all such problems, on the development of hardier strains of planting stock, on the possibilities of extending tree planting to more difficult soils and sites, on the formation of belts for special services, and to answer many practical questions farmers and foresters in the area are asking.

The Shelterbelt Project has been a success.

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NEW USES FOR WOOD

While the demand for sawn wood from all the war-damaged countries in Europe is far greater than it was before the war, and will be for years, new uses for timber are always arising, and the percentage of forest products which is actually sawn into deal, batten and board dimensions tends to diminish. There are now very many by-products to be obtained from wood, and, in addition, wallboard, plywood, plastics, etc., all absorb a certain quantity of timber. But there is one industry, the wood pulp trade, which is a direct and very formidable competitor and which for many years past has been absorbing ever-increasing quantities of the raw material which formerly went to the saw mills. The universal demand for paper is enormous, and there scarcely seems to be a limit to the quantities of pulp which can now be used. When the pulp industry was in its infancy, the effects on the production of sawn goods were not very noticeable, all the large logs continuing to be reserved for sawing, only the small dimensions and mostly whitewood being bought for the purposes of pulp manufacture. Very rapidly, however, the demand for cellulose expanded, and the pulp mills began to compete with the saw mills for the bigger dimensions, as there was much more profit in the manufacture of pulp, and this caused increased competition for the raw material. The finer quality wood in the large logs was not needed for the pulp industry, but for the smaller logs and inferior qualities, competition increased, and slowly the bigger logs began to drift to the pulp market.

In all countries in which the cellulose industry was developed the competition of the pulp mills became very severe; in Sweden the high prices paid by pulp manufacturers at log auctions tended to raise the whole value of wood prices, and sulphite paper pulp, sulphate paper pulp, mechanical pulp and newsprint were manufactured in ever-increasing quantities. Of course, the growing use of pulp does not diminish the demand for sawn goods in these times but it certainly does affect the supply, and is probably one of the hidden causes which will make a return to more moderate figures for sawn wood a very slow process. As, however, the vast forests of Russia are more effectually exploited, the total volume of timber on the market will expand, and as it takes longer for the pulping industry to develop in new areas, it is probable that the first export of forest products from hitherto untouched forest areas will consist largely of sawn goods.

On the question of prices, there are now few people in the trade who expect to see again the vast production of sawn goods at the ridiculously low prices of former years. Before the 1914-1918 war we can well remember good Hernosand 3 x 9 unassorted red being offered at five guineas f.o.b., and, in the inter-war years, of unassorted 7in. Finnish battens quoted at £7 15s. Such figures even then were not remunerative and, as the trade can readily call to mind, measures had to be taken by the European Timber Exporters' Convention to limit the yearly quantities of sawn goods to be exported from the various European countries. The necessity of such a measure shows the vast possibilities of the sawn wood exporting trade, and the recollection of these events is ever present to those engaged in the timber industry in this country. For, despite all the other modern uses of wood and all the demand for the raw material for purposes other than building and constructional work, the export possibilities of Russia, Sweden, Finland and Central Europe will be as great as ever, and as the Soviet Government under the next Five-Years' scheme are planning to spend great sums on the better organisation of their forests and of their railway system, it is only a matter of time before a buyers' market will develop. When this will happen is a problem.

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CONTOURING IN PRINCIPLE AND PRACTICE*

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I. In Principle.

It is important that all soil conservation workers should grasp the essential principle of working along the contour as this is the only sound basis on which surface water can be controlled and stored. Contouring is any practice which drives a plough furrow, ridge, or ditch on the level and along the hillside, that is, on the contour. The ultimate object is the control of soil erosion in areas of high rainfall and the conservation of all available moisture in areas of low rainfall. Contouring will pay dividends in the increased yield of every type of crop, whether cereals, commercial plantation crops, grass, or trees.

All phases of water catching are included in this one term, *viz.*

(1) the ploughman's furrow, either covering the entire field or only run at spaced intervals,

(2) a double turn of a plough to throw up a ridge either 2 furrows back to back, or in multiple,

(3) shallow trench and ridge,

(4) deep trench and ridge,

(5) Bijapur *bund* built out of shallow borrow pits into a more or less triangular cross-section,

(6) *wattbandi* with a contour *bund* built out of soil scraped from all over the field to form any shape of mound,

(7) the American broad-based terrace, with the cut and fill forming a much flattered hump and hollow. The only essential difference between the "Mangum" and the "Nichols" pattern is that the Mangum is more hump than hollow while the Nichols is more definitely an excavated ditch,

(8) basin-lister or scoop machine, making the entire field surface into a dense pattern of 10 ft.×3 ft. basins,

(9) typical rice-field pattern of small plots completely levelled and each with a puddled clay *bund* round the downhill edge,

(10) bench terracing, commonly used on hillsides too steep to permit of a *bund* raised above the level of the *field itself.* Each banch is a flat step between the inside hill face and the outer terrace wall though the ideal is to have a slight reverse slope into the hill and thus secure a good catch of water.

The success of any of these types depends upon accuracy of alignment true to the contour; improperly constructed ditches and furrows may add to the erosion rather than stop it, as is frequently the case when a series of short interrupted trenches (often but wrongly called "contour trenches") divert water on to the edges of gullies already cutting actively.

The only justification for departing from the strict contour is when long lengths of terrace carry so much run-off that there would be a constant risk of breaching unless the water were drained off. This can be done by aligning the *bund* or rather the channel behind the *bund* on a slight slope as is done in the case of a diversion ditch, whose function is not to hold up still water but to lead it gently away; this is known as the *graded channel type;* details of which are given at page 395.

II. Contouring in Plough Land

Three Topographical Classes.—These notes are restricted to plough land only. The capacity of rain for destroying and removing unprotected soil is terrific; falling at 20 m. p. h. as is frequent in storms, 2 inches of rain per acre produces 6 million foot pounds of kinetic energy, much of which is expended in loosening, churning up, and removing in suspension the most valuable crumb structure of the top soil. In considering erosion losses fields may be grouped roughly into

*Paper read at the Seventh All-India Silvicultural Conference, Dehra Dun (1946), on item 4—Contour bunding and trenching as counter erosion measures.

3 classes according to their topography :—

(*a*) Comparatively flat *barani* cultivation. Most people think that erosion is not a serious matter on such land, but the run-off data for the Sholapur Experimental Farm in Bombay collected by Mr. N. V. Kanitkar, showed a loss of 133 tons of soil per acre per annum from a well tilled field on a gentle gradient of 1 in 80, indicating a very serious state of affairs where one would least expect it.

(*b*) Gentle slopes in the highly eroded foot-hills and in the rolling sandy uplands such as the Punjab Doaba. Here the need for contour terraces and contour ridges (*wattbandi*) is fully appreciated by many cultivators but unfortunately is not practised consistently. It is most fully practised in the arid districts *e. g.* Mianwali, and the standard deteriorates as the rainfall improves and the need for saving every drop of rain becomes less urgent. The cumulative run-off from big blocks of such rolling land forms a serious problem unless every field is fully fitted with *watts*, and often spillways are also needed.

(*c*) Steep slopes where permanent cultivation is possible only with elaborate terrace walls of stone or turf. Unterraced cultivation on steep slopes known variously as "shifting cultivation", *nautor, rab, etc.*, is inevitably so destructive that after a few years the field reverts to stony scree.

The protection of ploughland from erosion can be reduced to (*a*) the protection of the surface against falling rain, (*b*) the infiltration of water into and through the soil, (*c*) leading off the excess in such a way as to deprive it of power to do damage.

In practice there are four lines of defence *viz.* :—

(*a*) maintaining a plant cover in terms of crops; leaving stubble after crop is cut; green manuring; or the sowing up of bare fallow with a protective cover, preferably leguminous but *kana* grass has great possibilities,

(*b*) maintaining the soil in a porous condition by means of manuring, mulching, and other tillage practices such as subsoiling,

(*c*) the interception of water by means of ploughing along the contour, the proper levelling of each field, and contour ridging or *wattbandi* by which each field is turned into a saucer,

(*d*) the proper construction of escapes at every stage from top to bottom of each block of fields and the disposal of accumulated run-off so as to render it harmless.

While these principles appear simple, departures from standard local practices require much careful investigation and practical trial before being applied. If the farmers' confidence is shaken by finding our advice on any one point is wrong, it may take years to recover this confidence.

Cures based on American experience.

(*a*) *Terracing.* The American broad-based contour ridge is out of the question for Indian bullock power and our usually shallow soils. We have to substitute either *wattbandi* (narrow based ridges) or reversed-slope bench terraces in which the whole of each field virtually forms a saucer.

(*b*) *Strip cropping* to break up big blocks of land under one highly erosive crop. This is not feasible for the ordinary small Indian field but might be practised by whole fields wherever a good alternative such as berseem or lucern is an accepted local crop, or where a leguminous cover crop can be introduced on bare fallow.

(c) *Abandonment of highly erosive crops* cannot be usefully recommended until we have found some equally marketable crop for the given soil and climate. Speaking generally the *method of field cultivation* is in India a far bigger factor in causing erosion than the *choice of crop.* In this connection the new American practice of carefully preserving stubble and crop residues of all sorts on the ground and preparing the soil for the next crop by cultivating along the contour and disturbing these old crop residues as little as possible is recommended for wide trial under Punjab conditions and particularly wherever dry farming is considered essential.

(*d*) Local demonstration on a *project basis* for selected catchments has in America been replaced by a *district organization* aiming at forcing every farmer in a whole district to adopt the recommended practices of field cultivation and land use. These district organizations correspond roughly to our soil conservation divisions for civil districts in which

the soil conservation circle is functioning, but with the difference that in the United States of America much of the driving force comes from an elected body of farmers who are given very large powers to coerce the unwilling minority into doing what it is told to do, funds being collected by levy or cess to supplement the funds allocated by government out of tax remissions.

Cures based on Indian experience.

(*a*) The one great contribution which India has made to the problem is the fact that individual fields have been kept fully productive for centuries by means of skilful terracing *i.e.* bench terracing in the case of rice lands and *wattbandi* for other crops. Where *wattbandi* is not already consistently practised, it can be fostered quickly and on a wide front by contributing grants or as an adequate remission of revenue to reward each man who puts his fields in good order. The need for remission or coercion has already been accepted by the Punjab government as necessary for important catchments and in our soil conservation divisions, but has not been applied generally to ordinary *barani* land.

(*b*) Much slower but acceptable progress can be made through *consolidation* of scattered holdings, particularly if the method and layout of the new field pattern pays sufficient attention to slopes, run-off, and natural drainage problems as affecting roads, fields and water tanks.

(*c*) *Partition of undivided shamlat* (common holding) is highly successful wherever there is a genuine land hunger. Fresh allocations of waste are rapidly made cultivable by energetic individuals, and the uncultivable remainder is closed to form private hay fields and small blocks of forest.

(*d*) Better farming societies, and land reclamation societies and panchayats all of which should have *wattbandi* as part of their creed and in their byelaws.

(*e*) Direct action by Agriculture and Forest departments by means of demonstrations, prizes to good workers, lectures and "weeks" may spur an intelligent minority but has little effect upon the lazy majority of cultivators, so that some threat of coercion must be provided by statute, and is available through the application of section 5-A which was added to the Punjab Land Preservation (Chos) Act in a 1944 amendment.

III. Recommendations for Contouring in Plough Land.

The Punjabi cultivator prefers square fields. Except in the single case of hill rice cultivation he has attempted to enforce a grid of square fields on to a country of round contours. The result has been (*a*) that the lowest corner of each field is the wettest and most easily breached, (*b*) that a great deal of unnecessary earth moving goes to make *watts* which depart from the contour. In the case of the rice fields on steep slopes he has realised that the cost of square fields would be prohibitive and he has therefore followed the contour; most individual rice fields are kidney-shaped because they follow the contours of the hillside. This is the principle which we wish to have adopted for all *barani* land, whether under agriculture crops, grassland or trees.

In the Punjab we have delayed proper contouring in the hope that at the time of consolidation of holdings the land will be contoured. In Bombay Presidency they have done better by carrying out the contouring first. The old field boundaries remain in use until consolidation is introduced, but at consolidation the contour ridges automatically become the new field boundaries, for by then the cultivators have come to appreciate their value. Contour cultivation must disregard old field boundaries and straight lines completely, following curved lines wherever this has to be done in order to stay on the level.

Contouring of fields is best understood in the arid zone where it is essential to ensure the trapping of the entire rainfall, but it is equally necessary in the wet zone in order to prevent erosion on land, that if unprotected, would suffer from gullying or sheet wash. It is equally important in flat land liable to suffer from wind erosion; for this latter, ridges are more effective than trenches, but on clay, furrows or trenches are better than ridges.

The idea is commonly held by many civil officials that one "*wattbandi* week" each year in a district is effective. It may salve the civilian conscience, but the fact remains that proper field technique is not gained through a burst of feverish activity once a year but is based upon a *habit of mind.* Run-off control only starts with the making of a *watt*; the rest of the cultivator's life must be a study of how this start in run-off control can be improved upon. Maintenance must be preached until it is done as a matter of course.

Another common misconception is that a *watt* to be effective must be an enormous engineering feat. This is entirely erroneous. On level land or gentle slopes on sandy loam the most efficient *watt* for wheat is a ridge about 1 ft. to 18 inches high and 2 to 2½ ft. wide at the base, running along the contour and repeated at intervals of say 12 to 15 yards. If these are accurately contoured they can take care of the whole of the rain of even very severe storms provided that drainage does not accumulate

and pass from higher fields to the lower ones of a block. Such frequent *watts* are however generally disliked by the cultivator as they interfere too much with his ploughing and bigger but less frequent *bunds* are therefore preferred.

The vertical drop between 2 consecutive *watts* is determined by the gradient and the minimum width demanded for ploughing. On land of less than 6% slope, 100 ft. width makes a reasonable field, but anything steeper than this quickly runs into difficulties, for *watts* on narrow fields take up too much of the ploughable surface until for 8% slope and upwards a bench terrace without a *watt* is preferable. A schedule is given below of recommended spacing and heights of *watts* based on American data but altered on the basis of contouring demonstrations actually carried out in various Punjab soil conservation divisions.

Table of recommended vertical falls between terraces in relation to land slope.

Slope			Vertical fall from terrace to terrace.	*Horizontal distance from bund to bund*		Type of work.
in feet per 100 ft.	in degrees.	Equivalent gradient (approx.)		average	maximum.	
1 ft. in. 100	0° 34′	1/100	2 ft. 0 ins.	180 ft.	230 ft. —	*Watt-bandi* and contour *ridging.*
2 ,, ,, ,,	1° 09′	1/50	2 ,, 6 ,,	120 ,,	150 ,, —	
3 ,, ,, ,,	1° 43′	1/33	3 ,, 0 ,,	100 ,,	140 ,, —	
4 ,, ,, ,,	2° 17′	1/25	4 ,, 0 ,,	100 ,,	110 ,, —	
5 ,, ,, ,,	2° 52′	1/20	5 ,, 0 ,,	100 ,,	120 ,, —	
6 ,, ,, ,,	3° 26′	1/17	6 ,, 0 ,,	100 ,,	110 ,, —	
7 ,, ,, ,,	4° 00′	1/14	5 ,, 0 ,,	60 ,,	80 ,, —	
8 ,, ,, ,,	4° 34′	1/12	4 ,, 3 ,,	50 ,,	55 ,, —	
9 ,, ,, ,,	5° 09′	1/11	4 ,, 6 ,,	45 ,,	55 ,, —	Bench terracing and complete levelling.
10 ,, ,, ,,	5° 43′	1/10	4 ,, 9 ,,	45 ,,	50 ,, —	
11 ,, ,, ,,	6° 17′	1/9	5 ,, 0 ,,	45 ,,	50 ,, —	
12 ,, ,, ,,	6° 51′	1/8	5 ,, 3 ,,	40 ,,	45 ,, —	
13 ,, ,, ,,	7° 24′	1/7½	8 ,, 0 ,,	60 ,,	70 ,, —	
14 ,, ,, ,,	7° 58′	1/7	5 ,, 0 ,,	35 ,,	40 ,, —	
15 ,, ,, ,,	8° 32′	1/6½	6 ,, 3 ,,	35 ,,	40 ,, —	
20 ,, ,, ,,	11° 19′	1/5	8 ,, 0 ,,	35 ,,	40 ,, —	

Nothing of over 20% (1 in 5) should be terraced, except by mattocking contours for grass or tree sowings, or by short lengths of interrupted but carefully contoured trenches for afforestation. This table shows that on slopes with a greater fall it will be necessary to build higher mounds and to reduce the distance between terraces according to the grader. Narrower and deeper ditches should be cut to occupy as little land as possible for such ditches and mounds cannot be cultivated. The upper limit of slope for which a ditch and mound is practicable for field cultivation is reached much earlier than where a very narrow edge is being provided for afforestation or *bhabbar* grass planting.

Where the soil is a clay or heavy loam which is likely to hold the water too long on the surface and damage the crop, big *watts* should not be made but instead a series of smaller *watts* 6 inches high and 1½ ft. at the base should be put in at closer intervals of about 15-20 ft. apart; (ploughing ought to be done along the contour and can therefore run between these *watts*). This is more or less the technique of the hill rice field applied to other crops. For certain crops such as cotton, deep accumulations of rain water are likely to be harmful particularly to a young crop.

Where the slope is steeper than 8% or 1 in 12, *wattbandi* becomes expensive and is less effective than benches separated by upright terrace walls

of turf or stones. The ploughable surface should be sloped back into the hill with a reverse slope so as to hold up water in the part deepest cut into the hill. Such terrace walls can be greatly strengthened with suitable hedge plants such as *Agave* and *Opuntia* and can be made to produce income by planting with fruit trees, *bhabbar* grass, bamboos and hedgerow timber.

Fields of a slope steeper than 1 in 16, should be withdrawn from ploughing as they are not usually worth the heavy labour of making benches very close together. The whole area should be planted with a parmanent crop such as *bhabbar* grass, fodder grass, bamboos or trees. All of these can be established more easily if the ground is dug with shallow trenches running along the contour, or failing this a carefully contoured ploughing with a heavy metal plough or digging in lines with mattock or *pharwa*.

On clay or non-porous soils where fields occur in big contiguous blocks some form of masonry sill is required for the escape channel. One spillway commonly used in the Punjab foothills is of brick and cement with a sloping front and costs about Rs. 25/-. The provision of a stilling pool at the bottom of the spillway is essential to stop undercutting of the structure by the seepage of water around the base of the wall.

The maintenance of *watts* in wheat land is seriously threatened by bare summer fallow remaining untouched until towards the end of the monsoon when ploughing begins again. The amount of sheet erosion caused by the early monsoon storms is immensely serious and could to a great extent be prevented by getting the ground ploughed and *watts* repaired before the monsoon breaks and again at frequent intervals through the rains.

When introducing run-off control measures for the first time in badly eroded land it should be realised that with the top soil already gone, the subsoil, often an intractable clay, is incapable of absorbing much water. Here spillways should be the basic pattern of the plan and the accompanying *watts* merely a means of leading the water towards each spillway. This will be particularly necessary when mechanical equipment is used to break down steep slopes, as an entirely new drainage regime will have to be worked out.

The entry of outside drainage on to blocks of fields from uphill should be prevented by diversion drains wherever this accumulation of water is likely to cause damage. On the other hand in areas of low rainfall, run-off from uphill can profitably be led on to the field to be absorbed there instead of being wasted.

For *watts* in sandy and porous soils no side slope should be allowed and the top of each *watt* should be dead level from end to end but should be built broader and stronger at points where *nakkas* or spillways are inserted and also where any natural dip in the ground behind is likely to collect much water.

For clays and other less porous soils a slight side slope should be given so that the bottom of the *watt* channel has a slight fall not exceeding 6 inches per 100 feet of its length. This will ensure that stagnant water does not remain indefinitely on surfaces which will not absorb any more. The following is recommended as an adaptation of American practice for establishing side-wise drainage in very long lengths of *watt-bandi* :—

Table of grading of side-wise (graded channel) drainage in relation to land slope and length of terrace.

Length of terrace in ft.	Land slope.		
	5% On clay soil	10%	15%
0 to 400	0	0	0
400 to 700	2	2½	2¾
700 to 1000	3	3½	4½
1000 to 1300	4	4¾	5½
1300 to 1600	5	6	7
	On sandy	soil	
0 to 700	0	0	0
700 to 1000	1¼	1¾	2½
1000 to 1300	1½	2½	3¼
1300 to 1600	2	3	4

The middle of the compartment will thus have dead level terraces but in a very wide compartment they will have a slight cant to either or both ends to ensure against breaching.

An analysis of old contour terrace areas in a variety of American soils shows clearly that terracing alone is not sufficient to stop field erosion. Other points which need attention in both planning and maintenance are :—(1) single units of field between terraces too broad, *i.e.*, terraces too wide apart for the given slope, (2) wrong location or absence of outlets and sills, (3) terraces too long, (4) higher catchment draining into terraced area, (5) too steep a side-wise alignment of terraces may allow erosion along their length (over 6″ drop in 100 ft.). ("A study of Old Farmer-Built Terraces" by Caines & Weld ; Journal on American Agricultural Engineering, Oct., 1941). To these may be added the common Punjab experience of neglected maintenance. In many Punjab districts *watts* were built by returning soldiers nearly 30 years ago but have since been neglected and remain as isolated humps in eroding fields. Similarly one finds brick spillways standing as isolated and useless tomb stones

in the alignment of a *watt* and *bund* which has not been maintained at the correct height and a cattle track or footpath has eventually dug so deep as to let all the water through there instead over the sill.

Increased yields of crops.—The following figures collected for six centres in Bijapur, Bombay, for the rabi harvest of 1943-44 give an idea of the comparative yields in bunded and non-bunded areas with and without Dry Farming operations.

	Average yield.		*Maximum yield.*		*Minimum yield.*	
	lbs.	p. a.	lbs.	p. a.	lbs.	p. a.
	Grain	Fodder	Grain	Fodder	Grain	Fodder
No Bunding .. No Dry Farming	274	507 (163 acres)	401	675	145	400
Bunding .. No Dry Farming ..	344	643 (234 acres)	625	1,246	158	310
Bunding and .. Dry Farming.	646	1,057 (295 acres)	916	1,530	386	747

Somewhat comparable increases in cereals and fodder grass crops, have been reported from all of the Punjab soil conservation divisions as a result of bench terracing or *wattbandi* as compared with the previous yields from the same land before levelling. But with thin soil and an infertile subsoil the crop output may be lowered for some years by *wattbandi* in the same way as often happens after deep ploughing.

IV. Contouring for Afforestation and Grass-land Improvement.

In the case of grassland and pastures with appreciable slopes American experience has shown that big *bunds* wide apart are less efficient than a greater number of small ridges placed closer together, *i.e.*, at shorter intervals down the contour, so that the pattern is reduced to that of ordinary plough furrows cut with a Raja or a mould-board or other heavy plough, cutting say 6″ furrows spaced 30 to 50 inches apart according to the prosity of the soil. A 3-inch rainfall can be held by furrows with half a square foot of cross-section, 2 ft. apart centre to centre. Porous soils need fewer furrows than this. When such land is eventually reopened to grazing these furrows will be less easily damaged by the animals than deep ditches and high ridges would be. On the whole, a furrow is better than a ridge because it revegetates more quickly and usually produces better quantities and quality of fodder grass. The furrow must however be reasonably large; *the ordinary country plough is useless.*

In the case of the deep trenches which were dug at Nurpur in Kangra in 1937 for checking the progress of natural grass recruitment, the ground was a very infertile subsoil clay exposed by years of sheet erosion, and the natural grass improvement has been very slow indeed, partly because the area has never been fully protected, and no planting of any sort was done. The expense of trenching in such areas is not justified unless it is going to be followed up energetically with planting and sowing of desirable species. On slightly more fertile loam and with complete protection, as we have had in the Polian-Jaijon trenches area of Hoshiarpur natural grass re-cruitment has been good and the 18-inch deep trenches dug in 1938 although very little silled are now invisible from the opposite hillside because the plant cover is so dense.

In the case of arid zone grass crops on level ground, the Hissar Livestock Farm have shown that a good and apparently permanent grass cover can be established on land that was previously completely wind-swept as it lay in the path of regular dust-devils, by means of ploughing with a heavy plough and doing a double turn every 15—20 ft. to build up a very small ridge into a criss-cross pattern known locally as *kiara-bandi.* The grass used is *anjan* (*Pennisetum cenchroides*). In Hissar practice this grass crop is cut for hay in years when the growth justifies it (possibly 3 out of every 5) and in the drier years it is grazed but the grazing is strictly regulated by keeping a fairly large number of animals on each field for a short time and moving them off as soon as the grass has been eaten down to a 4 inch stump.

Most of our work with *bhabbar* grass (*Eulaliopsis binata*) which is earning very large sums of cash for the foothill villagers, has shown that although it takes many years for ordinary transplanted clumps on a sloping hillside to become sufficiently well established to give a worthwhile commercial yield, the same size of transplant in the immediate neighbourhood of a trench gets into its stride very much quicker. Trenches on poor sandy soil under a thin canopy of *chir* pine in Sidh Ghaler, Hoshiarpur division, gave a yield per acre of 0, 5, 10 and 15 maunds in the first 4 years after planting on trenches as compared with hardly any appreciable increase beyond the 5 maunds per acre of the second and subsequent years from untrenched hillside planting.

In the case of the Silviculturist's four replications of arid zone afforestation plots for areas with a rainfall of 6″, 9″ 14″ and 20″, a similar type of *kiarabandi* to the Hissar grass sowing technique was used and the results obtained have been most encouraging with a survival into the third year of something between 2,000 and 4,000 plants per acre with all the species tried, namely *Acacia arabica*, and *Ansfarnesiana*, *Prosopis glanduflora* and *P. juliflora* and *Salvadora eleoides*. This was achieved with considerable attention to soil working and mulching which is an absolutely essential part of the technique.

Further evidence of the value of water catching for afforestation crops is to be seen in the Pabbi hills of Gujrat where work has been in progress off and on since 1866. Where sowings have been done on the open slopes without any form of water impounding, *Prosopis* trees which must now be of any age up to 40 or even 70 years old have put on very little increment and the wood is so dense that the individual rings are hardly distinguishable, whereas the same species and even more exacting ones such as *Dalbergia sissoo*, *Albizzia lebbek*, and *Gmelina arborea* have produced trees of 10″ diameter in 20 years in the neighbourhood of the earth *bunds* behind which the greater part of the local rainfall is stored beyond the monsoon season.

The import of all this is clear. If we are ever to grow either shelter-belts or timber trees in the arid zone we must concentrate upon the details of a successful technique of catching all the rain.

In the choice as between short lengths of interrupted trench and continuous and fully contoured berms there can be no doubt about the higher efficiency of the latter type, and a continuous line accurately contoured should always be aimed at except where the ground is so steep and stony as to render this impracticable.

V. Cost of Terracing and Trenching by Hand

The cost of all forms of contour ridging will be higher in sticky clay than in loamy soils so that the reclamation of badly eroded uplands will inevitably cost more than the improvement of areas which have remained in cultivation and have been looked after by the cultivators. The financial return is also likely to be less from neglected land as it will inevitably take many years to rebuild the former fertility and the actual operation of building any sort of terrace will tend to throw up less fertile subsoils to the top so that some years of poor crop yields must be expected until the new top layer has become weathered.

The actual cost of digging or ploughing can be roughly estimated on the basis of the work entailed, but will not cover subsequent operations of sowing, resowing, weeding, mulching, repairing breaches etc., and it is in these latter that the extra cost on clay soils becomes apparent rather than in the initial operation.

Ploughing any average acre of sloping land with a Raja plough may be taken @ 12/-. Digging $10\times1\times1$ trenches at 15 ft. horizontal interval and with a berm continuous along each contour row costs 16/- on the basis of $1\frac{1}{4}$ annas per trench. Any combination of spaced furrows cut either by plough or by hand should cost less than this. A deep trench and ridge of the Jaijon type, and a Bijapur *bund* with shallow borrow pits will both cost about the same per running foot, so the cost per acre varies considerably with the horizontal spacing required. As practised in the dry areas of Bombay Presidency this consists of a complete net work of low *bunds* laid out strictly along the contour, averaging size 8 ft. base $\times$ $3\frac{1}{2}$ ft. height $\times$ 2 ft. top width but shape and size varies in different soils. The horizontal spacing (mostly on very shallow slopes) is 70 ft. apart. The cost averages Rs. 12/- per acre with famine hand labour but this includes the cost of survey and alignment and some overhead for superior staff. The owners are asked to repay 25% of the cost in easy instalments, and there is legal provision to enforce proper maintenance of the *bunds* once made, (a very essential point). On gentle slopes unobstructed by tree growth the shallow borrow pits are cheaper, but on steeper slopes carrying scrub forest the Jaijon trench and ridge is cheaper and more efficient as a water conservation measure.

Bitter experience in the Uhl valley has taught our Punjab department that the trenching of very steep slopes is quite impracticable. The steeper the hillside the more the work will cost for anything more than a single plough furrow, owing to the difficulty in providing a stable outer edge to the trench. It is important to remember

that there is an economic upper limit of slope for any elaborate form of terracing, and we should keep strictly to the well established American convention that any land of over 20% slope (1 in 5) *should not be terraced.* Reclamation of all land steeper than this must depend upon less ambitious types of soil working. For all lands steeper than this it would be wise to keep to mattocking contour lines with a *pharwa* or mattock until we have acquired more experience in the use of machinery. Experts differ as to the steepest hillside on which a D 2 or Ford Ferguson tractor of the small compact type can profitably be used for afforestation on cut ledges. The British convention is 1 in 2½, but Assam and Burma war-time road-building points to this being easily exceeded, and thus opens up no great possibilities fort he reclamation of hitherto unproductive hill jungle land, particularly in areas of low rainfall.

The cost of *wattbandi* and contour ridging to render land fit for cultivation is very much heavier than any of the above types of work and in actual practice using bullock-drawn *karahs* varies from Rs. 40/- per acre to Rs. 250/- per acre according to the slope and the hardness of the deeper layer which have to be ploughed or broken before they can be shifted with the *karah.* These costs are for slopes of 4% to 10% but are higher than they need be owing to the Punjabi's fetish for making square fields. Costs are usually kept to a minimum by organising *mangali* teams of friends and neighbours who receive a day's food for themselves and their plough bullocks. The cost of making true bench terraces on the steeper slopes of hill land depends upon many factors including the standard of walling which the owner is prepared to build. The general standard of work found in the hills and foothills is so low that actual costs if quoted would tend to show that this work is cheaper than *wattbandi,* but this would be entirely erroneous. Bench terracing of steep land if done thoroughly either with turf walls or dry stone walls must obviously cost more than the contouring of more gentle slopes.

VI. Cost of Terracing with Mechanical Equipment

In America where terracing is being done on a very large scale, highly trained engineers and skilled machine operators are invariably engaged. Wages there are high, yet the cost is comparatively small and well within the means of the smallest farmer. In most states extension work in agriculture and home economics is carried out on the co-operative system and the method of financing terrace projects is interesting. The county board of revenue, which is the appropriating board of the county, underwrites the purchase price of the terracing plant and the Department of Agricultural Co-operation make a charge to the farmer on whose farm the work is being done, of three dollars per hour for the terracer and four dollars per hour for the bulldozer for the actual time spent on the job. These charges include a tractor operator and machine operator for the terracer and an operator for the bulldozer. The charge also includes a surveyer and rodmen who are engaged on laying out the terrace lines just ahead of the machinery. The surveyor is usually the foreman of the party. Of course the hourly rates include fuel-oils, greese, lubricants and depreciation. Under normal conditions one dollar per hour goes towards the purchase price of the equipment and instruments. The Indian equivalent is Rs. 8/- per hour for terracers and Rs. 10/- per hour for bulldozers.

To convert this basic cost figure into an acreage cost brings in so many factors that it is foolish to give any empirical figure. The bulldozer reclamation of ravined lands by an army unit at Kharian in Gujrat district has shown that in large blocks of ravines 10% of the area can be made into cultivable fields at a cost of Rs. 50/- per recovered acre but that if half the total acreage is attempted costs go up to Rs. 400/- per recovered acre, whereas a cent per cent recovery in deeply ravined land will cost at least Rs. 800/- per acre. This is for fields. For afforestation of course such elaborate levelling is quite unnecessary and the value of machine power lies in the facility with which water holding *bunds* can be thrown up at intervals all down each *nala* bed. For ordinany terracing on gentle slopes not deeply ravined a D 4 pulling a 10 ft. terracer can make half a mile of terrace in an 8-hour day at a working cost in labour, fuel and oil of Re. 1/- per 100 running feet of terrace.

NATURAL REGENERATION OF TEAK IN MONG MIT FOREST DIVISION, SHAN STATES, BURMA.

BY F. ALLSOP

(*Principal Forest Officer, Shan States*).

In parts of Mong Mit forest division, Shan States, Burma there is much natural regeneration of teak (*Tectona grandis*), presenting interesting problems in regard to tending. The regeneration is, in many localities, as dense as in a normal plantation. It is found in moist and dry upper mixed deciduous forest and also in a drier type where *Dipterocarpus tuberculatus* (*in*) and *Pentacme suavis* (*ingyin*) are the predominant species. In the latter type teak does not grow to economic sizes and will not, therefore, give a return for money spent on it, but under moister conditions tending is likely to yield valuable returns. The chief species found in association with the teak are *Dipterocarpus turbinatus* (*kanyin*), *Sterculia* spp. (*shaw*), *Duabanga sonneratioides* (*myaukngo*), *Tetrameles nudiflora* (*baing*), *Protium serratum* (*thadi*), *Lannea grandis* (*nabe*), *Dillenia pentagyna* (*zinbyun*), *Adina cordifolia* (*hnaw*), *Anthocephalus cadamba* (*ma-u*) and *sarcocephalus cordatus* (*ma-u-lettanshe*) in the moist and *Terminalia tomentosa* (*taukkyan*), *Terminalia chebula* (*panga*) in the dry upper mixed deciduous forests. The commonest bamboo is *Cephalostachyum pergracile* (*tinwa*), moie or less luxuriant according to moisture conditions. Gregarious flowering of this bamboo has probably provided the opportunities for the teak regeneration to obtain a footing.

There is an abundance of epiphytic *Ficus* and of climbers throughout the forests under discussion.

The most important and extensive areas of this natural regeneration have been listed and mapped, and some 8000 acres were included in a tending scheme incorporated into the 1937—47 Mong Mit divisional working plan. It is by no means certain that all the areas that would justify attention have been recorded and there is a probability that the scheme will need extension as others are discovered.

The prescriptions for tending are still to a large extent experimental. Those given in the plan were on broad lines and their results are not yet fully apparent. Funds are not, of course, unlimited, and labour is short, so it is important to use both to best advantage. This article is written with a view to obtaining useful suggestions from experience of similar work elsewhere.

The objects of the tending operations in the naturally regenerated teak areas are to give the concentrated groups of sufficient size special attention on the lines of that given to teak plantations and at the same time to do everything possible to help the teak and, within the range of economic extraction, other marketable hardwoods, in the remainder of the compartments where teak regeneration occurs. Patches of teak covering less than 5 acres are tended along with the bulk of the compartment, only blocks of 5 acres or more being mapped and scheduled for more intensive tending.

Detailed instructions for both types of work are as follows:—

(1)—Operations outside the scheduled natural teak regeneration areas where teak (and other hardwoods if salable) is likely to attain exploitable sizes:—

Note:—Dry forests, where scrubby teak is often very plentiful, should not be touched, nor should good quality forest if non-teak-bearing and beyond the range of extraction of other hardwoods.

(*a*) Cutting of climbers on all teak, small and large, and on all trees from which climbers are likely to cross over to teak.

(*b*) Felling of useless species, including bamboos, interfering with groups of teak or patches of promising teak regeneration. Single teak trees or groups of only two or three are ignored.

On the assumption that trees which have already reached or are approaching feet breast height girth are so near maturity that they will not respond sufficiently to fellings intended to free them from interference to justify the expense, groups in which the larger girth classes preponderate are left alone except for cutting of climbers.

NOTE:—Where hardwoods other than teak are salable, the operations described in (*a*) and (*b*) are extended to benefit *Xylia dolabriformis* (*pyinkado*), *Ptero carpus macrocarpus* (*padauk*), *Dipterocarpus turbinates* and *ssp.* (*kanyin*), *Dipterocarpus tuberculatus* (*in*), *Shorea obtua* (*thitya*), *Pentacme suavis* (*ingyin*), *Gmelinaarborea* (*yemane*) and *Adina cordifolia* (*hnaw*).

(*c*) Felling of suppressed teak in the groups where cleaning is due under (*b*).

(*d*) Felling of all *ficus*-bound trees of unsalable species in areas where teak and other hardwoods (if salable) are likely to grow to economic sizes. A *ficus*-bound tree is defined as a tree covered by *ficus* to the extent of half the circumference at any point in the bole.

Marketable trees infected by *Ficus* are removed in the normal course when exploitation takes place. Danger of infection from the large number of *Ficus* spp. left is fully realised but the expense of felling them is prohibitive.

(2)—Additional operations carried out in natural teak regeneration already mapped or in any new areas found :—

(*a*) Thorough cleaning, cutting out all useless species, including bamboos, interfering or likely to interfere with the teak, but leaving undergrowth for protection of the soil.

Where sapling growth preponderates and wild elephants are common it is advisable not to follow this prescription. The elephants take a delight in wanton damage to teak saplings standing in the open and in localities favoured by elephants there seems no alternative to leaving sapling growth to struggle with weeds and competitors till it reaches the stage when it is too woody to be attractive to these animals.

(*b*) Felling all suppressed teak.

(*c*) Thinning on lines that would be adopted for a teak plantation. The table, extracted from Indian Forest Records, Volume IV-A, No. 1 "Yield and Stand Tables for Teak plantations in India and Burma" provides a useful guide to spacing.

Spacement Table.

Showing average distance between trees by average crop diameter.

(All site qualities together.)

Average crop diameter	Mean spacement (triangular spacing)	Average crop diameter	Mean spacement (triangular spacing)
Inches	Feet	Inches	Feet
2 ..	7½	16 ..	30½
3 ..	9	17 ..	31½
4 ..	11½	18 ..	32½
5 ..	12½	19 ..	33½
6 ..	14½	20 ..	34½
7 ..	16½	21 ..	35½
8 ..	18½	22 ..	37
9 ..	20	23 ..	37½
10 ..	22	24 ..	39
11 ..	23½	25 ..	40
12 ..	25	26 ..	41
13 ..	26½	27 ..	41½
14 ..	28	28 ..	43
15 ..	29	29 ..	44

The number of trees per acre with triangular spacing is given by the formula :—

$$\frac{43560 \times 1.155}{\text{Square of side of triangle in feet.}}$$

The thinning needs to be done boldly to give the good stems room for adequate crown development and adequate light for establishment of abundant undergrowth. It is preferable that mis-shapen and damaged stems should be removed, but not at too great a sacrifice of regular spacing. Coppicing back of defective saplings is inadvisable as it only creates more potential victims for the elephants.

Teak trees which can be expected to reach the exploitable girth in 30-60 years time are not removed in this operation, even in favour of fairly large groups of younger teak, a certain yield 30-60 years hence being of more value than a potential yield 150 years hence.

Consideration has been given the possibility of treating the more advanced areas of natural regeneration the same way as the older teak plantations in Burma. When the plantations reach the age of about 40, the modern practice is to give them a final heavy thinning and thenceforward to treat them as part of the natural forest, giving them such attention as the latter receives. It is estimated that an average crop diameter of about 12" would be the appropriate size for the final heavy thinning in natural teak regeneration, but the crops so far encountered in the field have been too irregular to give this idea a fair trial without sacrifice of trees which can be expected to be exploited in the next felling cycle or the one after that. If suitable areas are found it is intended to open out to about 35 feet triangular spacing and to do no more special tending.

In the modern rules for marking teak for felling there are included instructions for carrying out simultaneous silvicultural operations, viz. :—

(*a*) the elementary sanitary operations of cutting climbers on or threatening all teak trees and of felling all trees infected with *Ficus* that are not already selected for exploitation ;

(*b*) in forests of sufficient value, more intensive operations, including, in addition to the measures prescribed in (*a*), removal of useless teak trees to benefit other teak trees, to release promising young growth and, on good soil, to make room for fresh regeneration. There is also provision for freeing promising young teak from useless neighbours, and thinning among the teak itself.

Where these rules have been adopted the tending operations discussed in this article will be much simplified. At present there are large areas not tended when the teak yield was last reaped and where the need for attention is urgent.

THE ORGANIZATION OF POST-WAR SILVICULTURAL RESEARCH.*

By A.L. Griffith, D.Sc.

(*Silviculturist, Forest Research Institute, Dehra Dun*).

The subject of the organization of silvicultural research was dealt with in great detail at the 1939 conference. During the war little was possible except to carry on a "care and maintenance" basis. The subject was again considered at the sixth conference in 1945. This conference reaffirmed the resolutions of the 1939 conference and particularly emphasised the need (1) for getting research work going again as soon as possible (2) for all provinces having silviculturists and adequate staff and (3) for the research staff being men suitable and trained for the job and adequately housed and paid.

One of the most important questions to be considered by this conference is the progress that has been made since the last conference.

A.—Forest Research Institute.

A reorganization scheme for the research institute has been put up to the government of India but not yet sanctioned. This affects the silviculture branch in several ways.

Under this scheme the soil chemist and the ecologist will become part of the silviculture branch.

A new statistical branch is being created under an expert statistician that will deal with all the statistical problems of all branches of the forest research institute and of the forest departments in the provinces. This has long been necessary. Part of the statistical staff of the silviculturist will be transferred to this new branch but the statistical assistant, the lower assistant, the head computor and four computors will remain to do all our sample plot, volume table, yield and stand table work as well as our own specialised problems. All general statistical probelems will be dealt with by the new branch.

A new publicity branch is also being created but as explained in the paper under item 2 this branch to start with will be almost completely occupied with liason work between the present utilisation branch, industry, and the forest departments in the provinces and it is unlikely that we will get much assistance from it for some years.

B. The Provinces.

Many developments have taken place in the provinces which we hope to hear about from the delegates but it is worth recording here that the North-West Frontier Province have appointed a silviculturist and have had him given specialist training in Dehra Dun and Sind have the post of Silviculturist sanctioned and it has been advertised to be filled by direct recruitment.

F. R. I. Press and Publicity Officer.

The question of whether the forest research institute should have its own press was gone into very thoroughly and it was decided that in order to deal with so many kinds of technical publications it would be better to utilize a number of presses that specialize in their work rather than to try and do it all ourselves. In addition it is doubtful if the volume of work would be sufficient to keep a big press, such as we would have to have here, fully occupied throughout the year.

As has been explained under item 16—PUBLICATIONS—we have been able to make temporary arrangements to clear off publication arrears and good progress is being made. Our trouble is that we have not the staff to produce the publications that need to be written. This will be discussed in a later paragraph.

Change of central silviculturist's programme from 3 yearly to 5 yearly.

At present the central silviculturist's programme is 3 yearly. It is almost entirely based on the silvicultural conference resolutions and these conferences are 5 yearly. It would save a great deal of work that is now done unnecessarily if the programme were changed to a 5 yearly one to bring it into line with the conferences. The programme could most conveniently start in the year following a conference.

Staff of the central silviculturist and provincial silviculturists.

The last conference emphasised the urgent need of providing full staff as soon as possible for silvicultural research work both at the centre and in the provinces. We hope to hear from the delegates themselves how the provinces have fared in getting their staff back to normal.

The position at the centre is the same as at the last conference 18 months ago. I still have no general assistant silviculturist and no statistical assistant silviculturist. As has been repeatedly pointed out this lack of staff is not because the

*Paper read at the Seventh All-India Silvicultural Conference, Dehra Dun (1946) on item—The organization of post-war silvicultural research.

posts do not exist and it is not because suitable men who want to come to Dehra Dun are not to be found in the provinces. Suitable men there are, and the deputation terms have recently been made much more attractive, but during the past 18 months since the last conference on several occasions provinces have been approached and have refused to release their men.

It is a very serious situation and something must be done about it. I recommend that the conference should pass a resolution in the strongest terms.

Training of silviculturists and silvicultural rangers at Dehra Dun.

In the past, the appointment and training of silviculturists and silvicultural rangers has been very haphazard and unorganized and I think we should now make recommendations to the Senior Officers' Conference on the subject. Whenever we have been asked to do so, as far as possible we have given specialist training to both silviculturist and silvicultural rangers but the whole system has lacked organisation and often when the man has been trained he has been quite quickly transferred to other duties where his training has been wasted.

I therefore suggest that—

(1) Silviculturists and silvicultural rangers should only be selected after a minimum period of district or range experience. I would suggest that they should do 3 to 5 years and should have experience in all the different major forest types of their province.

(2) Silviculturists and silvicultural rangers should have at least 6 months specialist training at Dehra Dun. This should preferably be of two periods of 3 months, one of which must be during the rains (June, July, August) when regeneration and tending experiments are going on. The second period in which chiefly office and record procedure, sample plot work etc. would be taught can be done at any time of the year.

(3) Silviculturists and silvicultural rangers if found suitable after a short period of probation should not be frequently transferred but should remain as specialists for at least 5 years. (My own experience is that it takes about 2 years to learn one's job and it is only after that that one becomes really useful to the province).

Visits to the forest research institute and to other provinces.

The importance of visits of silviculturists to the forest research institute to keep up-to-date with current research and to other provinces to study problems similar to their own cannot be overemphasised.

It formed part of the resolutions of the 1934 conference and has been reaffirmed at the 1939 and 1945 conferences. *It has also been accepted by all local governments and in consequence if silviculturists do not get around as much as they should it is their own fault.* I suggest that the conference should once again reaffirm this principle and draw the attention of the senior officers' conference to its importance.

In the course of correspondence about this conference and in the papers submitted to it, it is noticed that a number of states particularly ask that the central silviculturist (and other specialists) should visit their forests. This we are only too pleased to do but have so much touring that we only go to the places we are particularly invited to visit. In addition of course all expenses of such tours are borne by the central government. I suggest that as the position is apparently not known to many states the conference should include it in its resolution on this subject.

In the paper by the silviculturist, Ceylon, he asks that the Ceylon silviculturist should be considered as a provincial silviculturist in the matters of visits to the forest research institute. This of course we should be only too happy to do. In addition Ceylon has many problems in common with neighbouring provinces and it would be to the good of all if the silviculturist, Ceylon visits neighbouring provinces and the neighbouring provincial silviculturists visit Ceylon. I suggest that this also should be included in our resolutions.

OF PLANTING IN PLANNING*

By D. R. Narasimha Murthy Row, B. A., M.F. (Washington) A. M. I. E. (Ind).

(Divisional Forest Officer, Working Plans and Forest Surveys, and Principal, Mysore Ranger School, Mysore State, Bangalore).

Planning of various kinds—short-term, long-range and post—war—is receiving increasing attention nowadays in all departments of all Governments, all over the world.

The engineer's plans for road making, flood control, and river-training works have to have an intimate relation with plans for planting, which is a branch of afforestation work that the professional forester is now being called upon to undertake intensively. Afforestation, in its turn, must go in step with the problems of land management and utilisation.

As a result of this common planning ahead, the necessity for co-ordination of effort in all departments, specially in allied departments, has come to light and the stage at which such co-ordination must start requires to be thought out with more and attention than hitherto. With regard to land generally, the agriculture and the forest departments are intimately concerned in their planning, and in the last analysis, a land management department has to come into existance with the chief object of evaluating and apportioning land most suitable for agriculture, pasture, and forest cover—excluding barren lands—in the most desirable proportion for each purpose to answer all the needs of the community as a whole. A national classification of land, therefore, is indispensable from this point of view, for a planting plan.

It is found in western countriers that a minimum of 25 per cent of land area must be under forest cover to ensure the wellbeing of a community inhabiting the region. In India, this percentage is as low as 15 per cent as an average. Besides, the concentration of wooded areas along its northern and western and outer Eastern boundaries further reduces this figure to 5 and 3 per cent over large tracts of this country, resulting in distressing conditions of living for the common man especially in the rural areas and it is the interest of this common man which is so much in the picture in India to-day in all planning, with our new-won freedom and newly-found dignity.

Such a condition of deficiency at the source by itself calls for a big increase in planting activity over the whole of India no less then in Mysore. In addition, as this increase in planting progresses, it becomes obvious, from the start, that PLANNED VEGETATION at its best should be our goal always and everywhere; whether in towns or cities, in rural areas or in inaccessible hills and foothills, and on the fringe of desert and as far into it as one can penetrate.

The incentive to planting on the other hand, is not great, and even tends to be absent, in the present circumstances; for, pressure on land is increasing on all sides and profits from crops like cotton, ground nut and mulberry, and more recently from food grain, are so much on the upgrade as to prevent the ordinary land-owners from thinking about crops which mature more slowly. Planned vegetation, therefore, becomes primarily the responsibility of the state and the more educated and thoughtful section of the public and its representative bodies like the district boards, municipalities, and village *panchayats*. A few foreign instances will perhaps suffice to show what is meant by planned vegetation for towns and cities, where plants are not only useful, but beneficial and cultural in their value. The French immigrants introduced Lombardy pine and maple in Canada decades ago for avenues and for ornamental as well as recreational purposes. Maple is now the national tree of Canada, as oak is of Germany, all because an early need was felt for planting and vegetation and every organisation in the region took kindly to one or other of the tree species for the purpose. In India, the uninterrupted popular avenue for miles and miles along the Baramula-Srinagar road is an outstanding example of this planting bias. Just as we in modern civilized society need a road-plan for our towns and traffic, we need, with equal force, a planting plan for our roads. There should be roadside avenues for shade and beauty, and thoughtfully planted traffic islands and triangular plots at road junctions and crossings, for safety. Where there are double traffic lanes in each direction, inter-planting of lanes with different species of trees with characteristically, differing crown-shape and height growth will add materially both to beauty and to safety, helping the hurrying traffic to keep to its side of the road with ease and understanding. Colour schemes may further be introduced by a proper choice of avenue plants and trees bearing flowers of different colours which harmonise and which are more effective

*Read at the 35th session (1946) of the Mysore Engineers Association, Bangalore on 20th November, 1946.

when planted together according to a pattern. This, then, is planned vegetation in a limited sphere relating to town and traffic.

It will probably be in place here to state a few general facts about forests and forestry to help readers to a clear understanding of what follows.

Forestry is the second largest industry in the world, agriculture being the first. It (forestry) includes a programme of raising new crops to replace the old as harvested. Planting is one of the methods of replacing such old crops, and it has therefore been a longstanding practice with foresters the world over. This experience is invaluable and needs to be fully geared to the proposed development organisations in various fields.

In all countries, forests have been looked upon as a source of profit by individual and private owners to be tapped as quick as possible to be later neglected and forgotten. The value of forest as a stabiliser of climate and other conditions of land has not been fully realised. The stark necessity of trees and forests for the economic well-being of the rural population is not also fully appreciated, nor is the fact that erosion control and sub-soil water conservation and supply are greatly aided by forest cover. Hidden virtues are always harder to see.

In illustration of these facts, mention need only be made of the Tennessee Valley Administration activities in the United States of America, which are being very keenly received in recent months, in this country. They have demonstrated beyond all doubt, the vital necessity of national planning to *include proper utilisation of soil and of the conservation of forest cover* wherever naturally found, and specially on hilltops and foot-hills. On similar lines, a far-reaching scheme for the control of the Damodar floods have been prepared by the joint labours of the Governments of India, Bengal, and Bihar, according to the following extract. "Afforestation and anti-erosion measures have been given a high place in the scheme. While the experts differed in other methods such as the type and location of the dams and other engineering problems, it was the unanimous opinion of the damodar flood control committee that it was absolutely indispensable that the upper catchment area must be brought under scientific management which will include not only regulation of fellings, grazing, and cultivation, *but also afforestation* and *construction of small earthen bundhs, plugging of gullies,* and *various other anti-erosion measures such as contour ridging and bundhing.* It was, I belive, the first time that the forest department war represented on a committee of this nature in India and I am sure that the views of the departments on the subject *of the part which vegetation plays* in holding up runoff, etc., were fully and completely accepted, not only by the committee but also by the Governments Concerned of (India, Bengal, and Bihar).

"That the committee and the governments accepted the forester's point of view, *only now,* for the first time is not to be taken to mean that the need did not exist before for such policy and its aceptance, nor, that the benefits of forests were not enjoyed as part of Nature's bounties. The truth about erosion and the preventive effects of forest cover was always there, even as gravitation existed and operated before its discovery by Newton. This aspect of the usefulness of forests and foresters is surely as contributing to general human economy the benefit of planning and co-ordination, even before things are well on the way to a beginning.

In the Punjab, canal bank planting has been taken over by the forest department and canal avenues are becoming a feature of the rural landscape in that province.

It is, thus, evident that the road and irrigation engineers, the town traffic departments, and the town planning experts all need to have a plantation plan and aim at achieving PLANNED VEGETATION in their respective spheres of planning activity.

Next follows consideration of large-scale planting to answer the domestic and industrial needs for firewood and construction timber of rural and urban areas.

You are all painfully aware of the shortage of firewood in all parts of India no less than in the thickly populated and highly industrialised towns and cities like Bangalore and Bhadravati. The causes that led to this shortage are generally known to be due to army demands in cantonments and the surrounding camps for troops in training and troop movement depots. It was not only a demand for immediate consumption but also one for building up reserves in all army depots. The Industrial demand for this commodity rose steeply in the same period and nearly always in and about the same centres, creating distress in many poor homes—a virtual attack on the hearth and home. All-round rise in transport and labour costs tended materially to worse the position of supplies. Above all lack of early attention to the impending shortage, increasing haulage, and absence of organisation led to a crisis in July, 1944 in Banglore at last.

Later, the board of agriculture in Mysore through its special sub-committee recognised the need to take steps for raising 40,000 acres of fuel plantations in the deficit areas. The commissioner for economic planning and development in his notes entitled "Introduction to the development schemes in Mysore" accordingly reiterated the need and provided for planting up with fuel trees 10,000 acres by the forest department in about 40 *taluks* of Bangalore, Kolar,

Tumkur, Mandya, and Chitaldroog districts, at the rate of 2,000 acres per annum during the next five years.

I had the good fortune to be asked to undertake the selection of suitable areas in four of the five districts above-named, from out of land not under the control of the forest department. All the Amritmahal Kavalas, Gomals, and unassessed waste lands, not otherwise disposed of, were listed up and information about these areas collected under the various heads:—extent of area, cattle census figures for the villages, surplus land available and quality class of the land, as far as possible for villages in the proximity of state forests and close to main roads, keeping in view future operational and movement facilities. The necessary information was gathered after a rapid field survey by two working plan range officers and a specially appointed sub-assistant conservator of forests with my guidance during the three months from May to August 1946. These selected localities were inspected jointly by me and the district forest officers of the several districts and the more promising among these finally chosen, making sure that only the most favourable and accessible localities came up for oparation in the early years.

This survey revealed that there was sufficient land of good quality for raising Casurina and Casurina—cum—Eucalyptus plantations in all the four districts, fourteen *taluks* of which have now been brought under the scheme. It is estimated that an average Indian village must have 60 acres of plantations to supply all its firewood and small timber requirements, the former to supply wood fuel for its cooking and heating purposes and the latter for agricultural implements and housing needs. With 17,501 villages in Mysore to be satisfactorily catered for planting acquires the statures of a major problem of national importance, particularly as benefiting Agriculture, in so far as cowdung now burnt as cowdung cakes will be released for manure. What Indian agriculture is losing from waste of cowdung in the form of cowdung cakes for heating purposes for lack of firewood is modestly estimated at 15 per cent. of the total of all kinds of manure at present consumed in the country. In their words, 43,000 sq. miles more land than the whole of India's present cultivation could be manured if proper provision were made for the supply of *wood fuel* to the villagers.

The cost of raising plantations works out to Rs. 50/- per acre as an average for all operation of formation, weeding and tending after which the plantations need us further attention except watch and ward to prevent injury to the crop generally. The yield of fuel at the end of 10 years at 25 tons per acre represents a return of at least Rs. 200/- per acre at site at the end of this period. This is incidentally sound finance.

In Bangalore, Kolar, and Tumkur Districts of the Mysore Province natural conditions of rainfall, soil and subsoil are fairly favourable to hope for complete realisation of these expectations, both as regards commodity and as regards investment. In Mandya district, however, despite unfavourable rainfall and soil conditions, similar results are expected from irrigated plantations of Casurina wherever irrigable land is released for planting operations.

The wet-fallow and seepage areas in this district may also be usefully planted up with Casurina, *bage*, (*A. lebbek*), swamp mahogany (EUCALYPTUS Species), and *babul* (*A. aralica*) to reduce swampiness, and are accordingly included in the above programme. This scheme of fuel plantations is, therefore, a double-barrelled argument in Mandya district—helping to eradicate malaria and supplying the growing demand for firewood, in addition to saving farmyard manure for better crops and greater acreage for cultivation. The question of planting up wet-fallow was discussed once before in the 1944 conference of this association, and the government have since allotted 642 acres of irrigable land for plantations in this district in consequence.

In the scheme now drawn up for Mandya, 1,200 acres in all will be planted up in the next 5 years. The engineers concerned deserve a word of praise for devoting a thought to planting and providing necessary facilities to the forest department in taking over the areas alloted for planting.

Planting is thus a national duty to be enforced by the State. Prevention of havoc in wooded areas, whether in private land, *jagin* or *inam*, is a vital part of national conservation and Madras has covered herself with glory by speedy legislation in this regard. Planting tending to planned vegetation is therefore everybody's responsibility, as it confers on one and all the benefits such as improved firewood supplies, park land, groves and avenues for recreation to both man and beast, and a smiling landscape as Nature's graceful compliment to human wisdom.

PINE WOODS THAT SERVED AUSTRALIA.

Wide Variety Of Uses For Hoop And Bunya Timbers.

By Charles Lynch.

Hoop and bunya pines, the sturdy native timbers that Australia found so useful in the manufactrue of aircraft in the dark days of the Japanese invasion threat, are now serving the Commonwealth in peace-time industrial expansion.

During the war the demand on them was so great that the stands of these two species in the forests have been greatly depleted, and they will have to be used wisely in the Commonwealth's post-war building programme.

Admirably suited for interior fittings in housing, the two pine woods have an important future. Both woods are peeled in the course of the manufacture of veneers, plywoods, matchboxes, match splints, and in the making of battery separators. They have also been found suitable for mouldings, panels, joinery, built-in fixtures, and for food containers.

Hoop pine has been used in large quantities for the manufacture of Australian butter boxes. It is completely safe for butter transportation, provided an anti-taint spray consisting of a mixture of casein and formalin is applied to the wood. This spray was developed by the Australian Council for Scientific and Industrial Research.

Other uses for both timbers include the making of cask heads, and in agricultural implements, broom handles, and printers' block mountings.

The wide and varied uses of the two woods have led to increasing demand for the products. Annual cut of the pines for 1944-45 was approximately 106,00,000 super feet in the round. Of this, the plywood and the veneer industry absorbed 1,50,000,000 super feet, and the remaining 91,000,000 super feet were converted into sawn timber.

Hoop pine has a commercial range which extends along the eastern coast of Australia, from a northern point in the State of New South Wales to Rockhampton on the eastern coast of the State of Queensland.

There are also a few limited areas in the Tully and Atherton Tablelands (which are located in the north-eastern portion of Queensland), and some trees also occur in the mandated territory of New Guinea.

Bunya pine is more restricted in its distribution, being found in the esatern Queensland watershed lying between Brisbane, the State capital, and Maryborough, along the coastal strip.

The trunk of the hoop pine tree is usually straight and cylindrical, and it has a thin, tough bark with a paper-like layer which tends to show horizontal bands or "hoops" when it is being peeled.

Bunya grows somewhat taller, but has a heavier crown. It bears edible nuts in large cones. These were particularly relished by aborigines. Animals, including wallabies, also eat the nuts.

Both species are closely related to the Norfolk Islands pine, to the Chilean pine, and to the Parana pine which is the most important timber in Brazil. The Chilean pine is commonly referred to as "monkey puzzle". The wood of hoop pine has a pleasing yellow-white to light-brown colour, while that of bunya has a pinkish tint.

It is sometimes difficult to distinguish between the two species, and they are frequently sold together. Both woods are light in weight, but bunya is the lighter of the two, being 28 lbs. to the cubic foot to the 33 lbs. to the cubic foot of hoop pine.

Because of its attractive colour, bunya is sometimes preferred to hoop, although its physical and mechanical properties are somewhat inferior. Both, however, are admirably suited to the manufacture of plywood and veneer for which secondary industry in Australia is now finding so many uses.

They possess the qualities of fine, close and even texture, creamy colour, and relative strength, and aslo stiffness and firmness.

Hoop can be peeled without any steaming process. This wood was the basis upon which the Australian plywood industry was largely built. The timbers are the most suitable Australian woods for all joinery work as they saw and dress easily.

Ratio of strength to weight is high, nail and screwholding capacity is excellent and neither offers any difficulties in gluing work.

Post-war developments in Australian secondary industry promise a bright future for the timbers that proved their worth in the time of the national crisis.

PINE WOODS THAT SERVED AUSTRALIA.

Wide Variety Of Uses For Hoop And Bunya Timbers.

By Charles Lynch.

Hoop and bunya pines, the sturdy native timbers that Australia found so useful in the manufactrue of aircraft in the dark days of the Japanese invasion threat, are now serving the Commonwealth in peace-time industrial expansion.

During the war the demand on them was so great that the stands of these two species in the forests have been greatly depleted, and they will have to be used wisely in the Commonwealth's post-war building programme.

Admirably suited for interior fittings in housing, the two pine woods have an important future. Both woods are peeled in the course of the manufacture of veneers, plywoods, matchboxes, match splints, and in the making of battery separators. They have also been found suitable for mouldings, panels, joinery, built-in fixtures, and for food containers.

Hoop pine has been used in large quantities for the manufacture of Australian butter boxes. It is completely safe for butter transportation, provided an anti-taint spray consisting of a mixture of casein and formalin is applied to the wood. This spray was developed by the Australian Council for Scientific and Industrial Research.

Other uses for both timbers include the making of cask heads, and in agricultural implements, broom handles, and printers' block mountings.

The wide and varied uses of the two woods have led to increasing demand for the products. Annual cut of the pines for 1944-45 was approximately 106,00,000 super feet in the round. Of this, the plywood and the veneer industry absorbed 1,50,000,000 super feet, and the remaining 91,000,000 super feet were converted into sawn timber.

Hoop pine has a commercial range which extends along the eastern coast of Australia, from a northern point in the State of New South Wales to Rockhampton on the eastern coast of the State of Queensland.

There are also a few limited areas in the Tully and Atherton Tablelands (which are located in the north-eastern portion of Queensland), and some trees also occur in the mandated territory of New Guinea.

Bunya pine is more restricted in its distribution, being found in the esatern Queensland watershed lying between Brisbane, the State capital, and Maryborough, along the coastal strip.

The trunk of the hoop pine tree is usually straight and cylindrical, and it has a thin, tough bark with a paper-like layer which tends to show horizontal bands or "hoops" when it is being peeled.

Bunya grows somewhat taller, but has a heavier crown. It bears edible nuts in large cones. These were particularly relished by aborigines. Animals, including wallabies, also eat the nuts.

Both species are closely related to the Norfolk Islands pine, to the Chilean pine, and to the Parana pine which is the most important timber in Brazil. The Chilean pine is commonly referred to as "monkey puzzle". The wood of hoop pine has a pleasing yellow-white to light-brown colour, while that of bunya has a pinkish tint.

It is sometimes difficult to distinguish between the two species, and they are frequently sold together. Both woods are light in weight, but bunya is the lighter of the two, being 28 lbs. to the cubic foot to the 33 lbs. to the cubic foot of hoop pine.

Because of its attractive colour, bunya is sometimes preferred to hoop, although its physical and mechanical properties are somewhat inferior. Both, however, are admirably suited to the manufacture of plywood and veneer for which secondary industry in Australia is now finding so many uses.

They possess the qualities of fine, close and even texture, creamy colour, and relative strength, and aslo stiffness and firmness.

Hoop can be peeled without any steaming process. This wood was the basis upon which the Australian plywood industry was largely built. The timbers are the most suitable Australian woods for all joinery work as they saw and dress easily.

Ratio of strength to weight is high, nail and screwholding capacity is excellent and neither offers any difficulties in gluing work.

Post-war developments in Australian secondary industry promise a bright future for the timbers that proved their worth in the time of the national crisis.

ANNUAL ATHLETIC SPORTS OF THE FOREST RESEARCH INSTITUTE AND COLLEGES, DEHRA DUN, 1947.

This pleasant function was held in the afternoon of Saturday, the 29th March, 1947, on the playgrounds of the Indian Forest College at New Forest. The grounds were gaily got up and presented a festive appearance. The weather was bright at the start of the sports; later in the evening a large cloud threatened to burst over the field but luckily kept off. Amongst the large number of visitors, were the Honourable Dr. Rajendra Prasad, Member for Food and Agriculture in the Government of India, the Inspector-General of Forests, Mrs. Hamilton, the Senior Rani of Kollengode and the Elaya Raja of Kollengode. The occasion was also marked by the presence of over 300 forestry students. The evening's programme proved extremely popular and the large gathering enjoyed itself thoroughly. Austerity tea was served, in keeping with the rationing restrictions still prevailing.

There were three competing units—

(1) the Indian Forest College—comprising of two classes,—one of the 1945—47 and the other of the 1946—48 courses;

(2) the Indian Forest Ranger College (consisting of four classes, two of the 1945—47 and two of the 1946—48 courses); and

(3) the staff of the Forest Research Institute.

As in previous years, the five events—Long Jump, High Jump, Putting the weight, Throwing the Cricket Ball and One Mile Race—were concluded on the morning of the 27th March, 1947. The main programme for the evening was gone through in a regular and workman-like manner; and all items were well contested. The Ladies Race was well supported; and Mrs. Hamilton, wife of the Inspector-General of Forests, was the deserving winner. Mr. Khanna, Instructor in the Indian Forest Ranger College proved too good for the others in the Officers Race in spite of the heavy handicap against him (because of his having won the race in 1946 also). The Indian Military Academy again came out easy winners in the Invitation Relay Race. New features of the evening's programme were handicap races for small girls and for small boys in the Estate: these items proved extremely popular.

The Institutional Athletics Championship was won by the Indian Forest Ranger College with 49 points, the Indian Forest College scoring 36 points. The Indian Forest College had the *distinction of securing all the first three places* in both the 100 yards and 220 yards races, while the Indian Forest Ranger College did so in the 120 yards hurdles race. The Indian Forest Ranger College were also easy winners in the tug-of-war competition.

B. Yessamy of the Indian Forest Ranger College Senior Class A Division, and D. C. Sharma of the Indian Forest College, Junior Class tied for the Individual Championship with 15 points each. Yessamy's strong points were High Jump, Long jump and putting the weight while Sharma was outstanding in short sprints. He was ably supported in these items by J.K. Ganguly of the Indian Forest College, Senior Class.

The Honourable Dr. Rajendra Prasad congratulated the winners and addressed the students on the need for taking greater part in games and sports, for always keeping up their keenness and enthusiasm for these outdoor and group activities and most of all, for constantly developing a true spirit of sportsmanship. Mrs. Hamilton, wife of the Inspector-General of Forests, kindly gave away the prizes and certificates to the winners.

Our thanks are due to Rev. Bro J. E. Foley of the St. Joseph's Academy, Dehra Dun, for undertaking the duties of Chief Judge for the Sports: to staff Sergeant Instructor GALETTLY of the Indian Military Academy, who acted as Chief Starter; to Mr. Sultan Mohammad of the Wood Workshops, Forest Research Institute *for helping with the manufacture of the various* prizes at the Wood Workshops; and to the various Officers of the Forest Research Institute and Colleges, who assisted in different capacities, in the successful conduct of the Sports.

The following were the results of the Sports:—

Event.	*Winners.*	*Time etc.*
100 yards ..	1st D.C. Sharma (IFC) 2nd P.T. Devassy (IFC) 3rd J.K. Ganguly (IFC)	.. 11.0 seconds.
220 yards ..	1st D.C. Sharma (IFC) 2nd P.T. Devassy (IFC) 3rd J.K. Ganguly (IFC)	.. 25.2 seconds
440 yards ..	1st D.C. Sharma (IFC) 2nd Satya Bhusan (FRI) 3rd Mohan Chowdhury (IFRC)	.. 57.6 seconds
880 yards ..	1st Satya Bhusan (FRI) 2nd Rajendra Singh (FRI) 3rd Belwal (IFRC)	..

EXTRACTS

SOME USEFUL WILD PLANTS OF THE DELHI PROVINCE

By Harbhajan, Singh, M.Sc.

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India with its wide range of soils, climate and altitudes possesses a wealth of plant material which still remains to be systematically studied and exploited. The present paper represents a small beginning in this direction and deals with the economic plant found within the confines of province of Delhi. A brief description is given of each plant, with short notes on its useful characters. This information in many cases is incomplete and much remains to be done by botanists, pharmacologists and others before we will be in a position to claim that we are making full use of our natural resources. Mention has not been made of plants useful as sources of timber, gum, resin, tannin and dye, etc., as very few such plants were met with in a truly wild state and that too in small numbers.

Edible Plants

Always of interest to the poor, wild edible plants have a greater importance to-day when we are faced with food shortage. Moreover, some of the wild fruits and edible weeds apart

from being palatable, have high nutritive value and afford a change in the routine dietary of the less-moneyed classes. The value of wild fruits is often better appreciated by a tired pedestrian who happens to find along his path some trees of the wild date (*Phonix sylvestris*), *jaman* (*Eugenia* Sp.) or mulberry (*Morus* Sp.), or a few shrubs of the wild *ber* (*Zizypus* Spp.) laden with ripe fruits; after tasting their fruits he feels that he can resume his journey with renewed energy. Some of the wild leafy vegetables have been found to be rich in vitamins and are tasteful when properly cooked. These plants should not be scorned simply because they happen to be growing wild. The following are the common edible wild plants of the Delhi province:

1. *Pot herbs*

Amarantus viridus L. (Amarantaceae). An erect much-branched, glabrous annual, 1-2 ft. high; leaves 1-3 in. long, ovate, flowers green, arranged in slender axillary and terminal spike-like racemes. (Plate XIV, fig. 1). It is a common weed of the rainy and cold seasons. The tender tops and inflorescences are cooked in the manner of spinach and purslane.

Amarantus blitum L. (Amarantaceae)—vern., *chaulai.* A glabrous, procumbent annual with small long-petioled, oblong-ovate leaves; flowers yellowish green, in axillary clusters. A common weed in moist places, flowering throughout the year. It affords several cuttings in the season. Not only the tops but the branches are also tender so that the greater portion of the plant can be used for cooking. A tall variety of this is often cultivated. All the aerial parts of the plant are edible.

Chenopodium album L. (Chenopodiaceae)—vern., *bathua, bathu.* An erect annual, sometimes growing high up to 10 ft. The lower leaves are rhombicovate, the upper ones mostly narrow, entire, generally white and mealy beneath. Flowers inconspicuous, arranged in cymose clusters forming long terminal panicles.

It is a very common winter weed of cultivated and waste places. It appears in summer also, but the summer plant is distinct from the winter plant in colour and habit of growth. Leaves and tender twigs are cooked alone or as is more common practice, mixed with young *Brassica* (*sarson*) inflorescences and gram tops. The presence of *bathua* is said to add to the flavour. This plant is very rich in potassium salts.

Digera arvensis Forsk. (Amarantaceae)—vern., *tandla.* A slender quick-growing, common annual weed of the rainy season. Plants up to 2 ft. high; leaves thin, mostly ovate, flowers pink, in axillary spikes (Plate XIV, fig. 2). The leaves and tops of the plant along with the tender inflorescences are cooked as a pot herb. It compares quite favourably with spinach.

Ipomoea reptans Poir., syn. *Convolvulus repens* Willd., (Convolvulaceae)—vern., *sarnali.* An aquatic trailing herb, common in ditches. Leaves 2-6 in. long, cordate or hostate at the base, cymes 1.5 flowered; flowers pale rose-coloured. Flowers during winter. The young shoots are eaten as a vegetable.

Portulaca oleracea L. (Portulacaceae)—vern., *kulfa, salunak*. A succulent trailing annual with spathulate or linear sub-opposite leaves; flowers yellow with fleshy sepals (Plate XIV, fig. 4). A weed of the sandy places, growing throughout the year. A variety with ascending branches and broad spathulate leaves is cultivated in gardens. It is much used as a pot herb and some people have a special liking for it on account of it acid taste.

Portulaca quadrifida L. (Portulacaceae). It can be distinguished from *P. oleracea* by the much smaller leaves and four instead of five petals. It is always prostrate with very slender branches and is more common than the preceding species. There is not much difference in the taste of either the raw or the cooked material of the two species.

Stellaria media Cyrill. (Caryophyllaceae). A very common winter weed. It grows well in moist and shady places specially in the gardens. A delicate herb with opposite ovate leaves; flowers small, white, in terminal leafy clusters or solitary in the leaf axils. When properly prepared, it makes an excellent green vegetable of good flavour.

Tribulus terristris L. (Zygophyllaceae)—vern., *Gokhru, bhakhra, bhankhra.* A prostrate, branched annual or biennial herb, so abundant in some places that it forms a green carpet on the surface. Leaves compound with 5-7 pairs of leaflets; flowers yellow, axillary; cocci of the fruit spiny (Plate XIV, fig. 5). It is commonly found in sandy and rocky places and comes up with the first showers of rain. Leaves when cooked with *moth* seeds (*Phaseolus aconitifolius*) and the two together pounded into a paste form an excellent dish.

EDIBLE FRUITS

(i) *Unripe fruits, cooked as vegetables.*

Momordica charantia L. (Cucurbitaceae)—vern., *karela.* Two distinct wild varieties are met with in the rainy season, one near Okhla and the other on the sides of the Western Jumna Canal. Both have small roundish fruits. The fruits of the Okhla variety lack the characteristic bitterness and the projections on the surface are not so pointed. The fruits of the other variety are bitter like those of the cultivated varieties.

Prosopis spicigera L. (Mimosoideae)—vern., ***Jand, sangar.*** A medium-sized evergreen, spinescent tree with creamy-white flowers in slender spikes, 2-5 in. long. Pods 5-10 in. long, cylindric (Plate XIV, fig. 3). Flowers in April and the pods which resemble the pods of *lobia* (*Vigna catiang*) in shape and size, are available in May. These are cut into small pieces and cooked like *lobia.* The local people, however, believe that its too frequent use causes disorders of the stomach.

Trichosanthes cucumerina (L. Cucurbitaceae)—vern., *jangli chachinda.* A slender climber seen on the roadside bushes on the Rohtak road between the villages of Shakurpur and Nanglci. Flowers white, with fimbriated petals; fruits small, roundish, having white streaks, ending in a short beak. The plants bear profusely. Fruits ripen in September-October.

Trichocanthes dioica Roxb. (Cucubitaceae)—vern., *parwal, parol.* A slender, mcre or less scabrous climber, commonly seen on *Capparis sepiaria,* on the sides of Western Jumna Canal. Leaves dehtate, flowers white; fruits 2-3 in. long, oblong, orange-red when ripe. Flowers and fruits in the rainy season, and village boys when grazing cattle pluck the green fruits and take them home for cooking.

Coccinia indica W. & A. *Cephalandra indica* Naud. (Cucurbitaceae)—vern.,*Kanduri, kundru* an annual or perennial climber occurring in association with *Trichosanthes* sp., but distinguished from these by the 5-angled cordate leaves. Flowers whit·; fruits oblong, smooth, bright-red when ripe, (Plate XIV, fig. 7). It flowers during and after the rains. The young green fruits are used in curries and it is said to be very useful for diabetics. Ripe fruit with sweetish pulp are eaten raw.

(ii) *Unripe fruits used in other ways*

Trapa bispinosa Roxb. (Onagraceae)—vern., *singhara.* An aquatic plant with floating leaves, sometimes found wild in the Najafgarh *jheels.* It is now much in cultivation. The spiny fruit is eaten raw after removing the shell. The powdered seed is used in many other ways.

Capparis aphylla Rot. (Capparidaceae)—vern., *karil, dela.* A much branched leafless shrub with spiny stipules; flowers red, in elongated racemes; berries $\frac{1}{2}$-$\frac{2}{3}$ in. in diameter, globose, red when ripe (Plate XIV, fig. 6). The flower buds and green fruits are pickled. As the shrub is quite common round about Delhi, poor people collect the green fruits and sell them in the bazar at the rate of about 6-8 annas a seer.

Acacia arabica Willd. (Mimosoideae)—vern., *kikar.* The tender pods are pickled in vinegar.

(iii) *Ripe fruits*

Capparis sepiaria L. (Capparidaceae)—vern., *heens.* The small round berries, black in colour, are sweet when ripe.

Grewia populifolia Vahl. (Tiliaceae). A shrub common on the ridge. Flowers white, fruits small, orange-red, available in early winter months. The well-ripened fruits are sweet and tasteful.

Zizyphus jujuba Lamk. (Rhamnaceae)—vern., *ber.* A medium-sized spiny tree with round fruits. Its fruits are much inferior to those of the grafted varieties; those of some varieties irritate the throat. Fruits ripen in December-January.

Zizyphus nummularia W. & A.—vern., *jharberi.* A thorny bush very common in dry places. The fruits, which are smaller as compared to those of the preceding species, ripen in October-November about two to three months earlier than those of Z. *jujuba.* It has distinct botanical varieties in respect of earliness and lateness, size and taste of the fruit. Some of the varieties have fruits with flavour rarely possessed by the cultivated *ber.* A *ber* fruit with the size of the cultivated species and flavour of the best varieties of *jharberi* would be a very desirable fruit. Women of the surrounding rural areas collect the fruits and sell them in the market. The retail price of the fruit is 3 to 4 annas per seer. It is said that after attending to their domestic work, some women are able to collect as much as five seers of fruits daily.

Cucumis pubescens Willd., syn. *C. maderaspatanus* Roxb. (Cucurbitaceae)—vern., *kachra.* A creeping annual with reniform leaves and bright yellow monoecious flowers; fruits oval, 3-4 in. long and 2-3 in. in diameter, usually spotted when ripe. Fruits ripen in September-October. The entire fruits including the seeds are edible when ripe.

Eugenia jambolana Lamk. (Myrtaceae)—vern., *jaman.* A large, evergreen tree, flowering in May. Ripe fruits which are oblong and dark-purple in colour come to the market in July. They are juicy and taken with a little salt are very acceptable. A round-fruited variety (*Eugenia jambolana* var. *microcarpa Thwaites,* vern., *jamoa*), with smaller fruits having little pulp inside is commonly found in rural areas. Its fruits are not so tasteful.

Salvadora oleoides Dcne. (Salvadoraceae)—vern., *jal, pilu.* A small evergreen tree common in the saline soils in Khadar and between the Grand Trunk Road and the Rohtak Road. Flowers appear in March and fruits ripen in May-June. The fruits are sweet and are commonly eaten. Another species, *S. persica* which grows in association with it has two varieties, one red-fruited and the other white-fruited. The red fruits have a characteristic irritating acidic taste, while

the white ones are not acidic and are pleasant in taste. This species comes in flower in November-December, about 2-3 months earlier than the true *jal*.

Cordia myxa L. (Boraginaceae)—vern., *lasura, lisaura*. A deciduous tree common in waste places round villages. It flowers during March-April and the fruits ripen from May to July. The fruits when ripe are round and light-brown in colour; the viscid pulp which is sweet is edible. Ripe fruits are also pickled. (Plate XIV, fig. 8).

Cordia Rothii Roem. & Sch. (Boraginaceae)—vern., *gondni*. A small tree often cultivated. On the southern ridge this tree has become well established. The fruit which are ovoid and reddish is brown in colour are usually sold in the market. The pulp is not so viscid as in *lasura*.

Solanum nigrum L. (Solanaceae)—vern., *makoh, makoi*. An annual herb with dark green foliage. Flowers white, small, sub-umbellat. Fruits small round, orange or black. The black fruits are more tasty than the orange ones. A very common weed, flowering all the year round.

Morus alba L. (Moraceae)—vern., *tut*. Fruits are $1\frac{1}{2}$ in. long, white or red, turning black when ripe; they ripen in May-June. Common on the Grand Trunk Road as a roadside tree.

Ficus palmata Forsk. (Urticaceae)—vern., *anjiri, kaimbar*. A shrub or a small tree very similar to the cultivated fig.

Ficus caria L. Leaves 3-5 lobed. Figs axillary, solitary or in pairs, globose or pear-shaped, yellowish purple when ripe. Figs ripen from June to October.

Ficus religiosa L.—vern., *pipal*. *Ficus bengalensis* L.—vern., barh., *barota*. *Ficus glomerata* Roxb. (*gular*). The fruits of these gregarious trees are also edible.

Phoenix sylvestris Roxb. (Palmae); wild date-palm—vern., *khajur*. A tall palm, quite common in Delhi province in waste places. Fruiting spadix long, drooping, golden orange in colour, appearing in April. Fruits about 1 in. long, orange-yellow in colour, ripening in May-June.

Fodder plants with special reference to famine conditions

The province of Delhi lies in an area which often experiences scarcity of fodder even in normal years. Over 60 per cent of the cultivated area of Delhi depends on the rains. Although the average annual rainfall of the province is about 22 in. in certain years, and not uncommonly for several years in succession, the total annual rainfall hardly exceeds 10 in. Thus the rainfall being insufficient and irrigation facilities meagre, the cultivator is often short of both food and fodder. In such times it becomes a matter of great urgency to find materials which could be utilized as substitutes. Since the starving cattle will eat almost any kind of plant, it is not to be assumed that all plants afford equally nourishing fodder and that all such plants can be called emergency fodder plants. In the latter category may be classed only those plants which are characterized by plentiful availability, succulence, digestibility and power to stand drought.

The following are the common famine fodder plants of Delhi province:

Zizyphus nummularia W.&A. (Rhamnaceae)—vern., *jharberi*. In protected places it is a gregarious thorny shrub, but in places where they are subjected to frequent cuttings, the plants are rather small. The leaves form a most valuable fodder. The branches along with the leaves are cut and chopped into fine pieces with the help of a *gandasa* (chopper) made by the village blacksmith. Since the branches are spiny, these are handled with a leather gripper *hathal* (a leather gripper put on the hand) made out of a coarse leather piece. The choppings are fed to the cattle alone or mixed with *bhusa* if it is available. The leaves are also stored by beating the leaves off the cut branches which have been dried previously. It is the experience of the local cattle owners that the leaves promote the secretion of milk. Bushes are cut twice a year; once in March-April and again in October-November. But when there is severe famine they are cut at any time of the year.

Acacia arabica Willd. (Mimosoidae)—vern., *babul, kikar*. A moderate-sized spinescent tree, scattered all over the province. It is freely lopped for fodder; green pods, tender shoots and leaves being given to cattle, goats and camels. It is specially useful for milch cattle, and is fed even in normal years for increasing the secretion of milk. The data [Sen, 1938] on the anlysis of green pods, ripe pods and crushed seeds given in Table I may be useful.

Table I

Analysis of green and ripe pods and crushed seeds of Acacia arabica.

——	Total ash	Crude protein	Fibre
Green pods ..	5.47	15.77	12.44
Ripe pods ..	6.24	14.64	16.5
Crushed seeds ..	7.43	14.64	14.8

Prosopis spicigera L. (Mimosoidae)—vern., *jand, sangar*. An almost ever-green, moderate-sized thorny tree whose loppings are valued for

sheep, goats and camels. The pods which contain a sweet pulp are a good food and are available in April-May.

Prosopis juliflora De.= *P. glandulosa* *Torr.* (Mimosoidae); Mesquite bean. A fairly drought-resisting plant, coming into leaf early in April, remaining green right through the hot weather. It is not indigenous to this area. It was first introduced by the Horticultural Department and planted on the ridge. Later, it spread to the rural areas and in some localities has become well acclimatized. It is a useful source of famine fodder. The pods are large, sweet, and succulent.

It is stated that the pods have a high nutritive value, as shown by their contents, 8 lb. of digestible protein and 50 lb. of starch equivalent per 100 lb. of pods weight. They can thus be used to make up the protein deficiency of such roughages as wheat *bhusa* and rice straw which when fed alone do not constitute a maintenance ration.

Some of the varieties grow into trees and are useful as a source of fuel.

Alhagi camelorum Fisch. (Papilionatae)—vern., *awasa.* This thorny perennial shrub is very abundant all over the province especially in the alkali areas. It comes in leaf especially in hot weather. It is readily browsed by goats and sheep and is a special food of the camel. Tender branches are also given to the cattle after chopping. The pods are sweet. Flowers and fruits appear in May-June.

Dalbergia sissoo Roxb. (Papilionatae)—vern., *shisham, Sissoo, tali.* A large deciduous tree, freely lopped in times of fodder scarcity. According to Lander and Dharmani [1924] *shisham* leaves possess a feeding value comparable to that of green oats. But animals are not able to tolerate more them 5 to 6 lb. daily excess causing diarrhoea. It can be made into fine silage. Fresh leaves are given mixed with *bhusa.*

Analysis of *shisham* leaves, according to the same authors, is given in Table II.

TABLE II

Analysis of shisham *leaves*

Moisture per cent	Dry matter	Ash fibre	Crude	Protein	Nitrogen free extract
71.54	28.45	2.95	5.59	5.11	13.65

The digestibility co-efficient is 143.35.

Ficus glomerata Roxb. (Urcaticeae)—vern., *gular.* A large deciduous fast-growing tree found along the banks of the Western Jumna Canal near Bowana and along the Badarpur-Mehrauli Road. Green leaves and the fruits are much liked by cattle. *A point in its favour* is that the more it is lopped, the better is the growth of the leaf-bearing branches. Fruits are in clusters borne on short thick leafless branchlets arising from the trunks and larger branches, and number sometimes more then one hundred in a cluster. Thus there is a good yield of fruits also. Leaves and fruits are given alone. In the bazaars a small bundle of five to six twigs can be had for a pice.

Ficus religiosa L. (Urticaceae)—vern., *pipal.* A large tree with spreading branches. It is a sacred tree for Hindus who usually object to its being cut. It is however lopped for fodder by both Hindus and Mohammedans in time of scarcity. New leaves appear about the middle of March and fruits ripen from May to June. Branches with leaves and fruits are given directly to the cattle. Like *Ficus glomerata* it is a fast-growing and heavy-yielding tree.

Ehretia laevis Roxb. (Boraginaceae)—vern., *papri.* A small tree with rather broad leaves, scattered in this area. The tender twigs are cut and fed to the cattle.

Pluchea lanceolata C. B. (Compositae)—vern., *rukhri.* A small, hoary-pubescent shrub with erect slender branches. It is very common round Gangatoli, a village on the Western Jumna Canal. New branches appear in the month of March, and again during the rainy season when they are eaten away by grazing cattle. On flowering the branches become hard, when they are not relished. The leaves are succulent and saltish.

Chrysopogon montanus Trin. (Gramineae). A drought-resistant perennial grass growing very abundantly on the ridge. It can give several cuttings in a year. Although the plants grow quite tall, heavy yields cannot be expected on account of the leaves being narrow and present chiefly at the base.

Cymbopogon parkeri Stapf. (Gramineae). A rather dwarfish, perennial drought-resisting grass.

Eremopogon foveolatus Stapf. (Gramineae). A sporadic grass abundant in rocky and dry situations especially in the neighbourhood of the New Cantonment. It is perennial. flowering for most part of the year. A good fodder grass, about $1\frac{1}{2}$-3 ft. tall; tillering moderate.

Cenchrus ciliaris L., and *C. setigerus* Vahl., (Gramineae)—vern., *anjan.* These are two important perennial pasture grasses, drought-resistant to a certain extent. For milch cattle they are very valuable. Fairly heavy yields are obtained.

Heteropogon contortus Beauv. (Gramineae). A good perennial fodder grass if used before

flowering. The glumes have long twisted awns which make the plant unfit for feeding. It can give heavy yields on account of its high tillering and fairly tall habit.

During the rains a number of herbaceous plants come up in the cultivated fields and waste places. These are freely fed to the cattle as green fodder before *jowar* and *bajra* are available for the purpose. These are *Digera arvensis* Forsk., *Amarantus viridus* L., *Chenopodium album* L., *Celosia argentea* L., *Atriplex crassifolia*, *Echinochloa crusgalli* Beauv., *Dactylectenium aegyptium* Beauv. (*makra*), *Dicanthium annualatum* Stapf. (*apang*), *Eleusine indica* Gaertn., *Brachiaria ramosa* Stapf., *Brachiaria distachya* Stapf., *Urocloa panicoides* Beauv., *Aristida adscensionis* L. and *Digitaria bifasciculata* (Trin.) Henr.

In winter these weeds afford good fodder: *Convolvules arvensis* L. (bindweed), *Lathyrus sativus* L. (*Khesari*), *Medicago denticulata* Willd. (*maina*). *Trigonella polycerata* L., *Melilotus alba* Desf., *Melilotus parviflora* Desf. (*senji*), *Vicia hirsuta* S. F. Gray and *Vicia sativa* L. (vetch)

MEDICINAL PLANTS

Transport difficulties occasioned by war conditions have brought into great prominence the problem of medicinal requirements of this country. Efforts are now being made to collect information regarding the types of plants growing plentifully in nature in different localities both in the plains and in the hills, special attention being paid to the finding of suitable substitutes for those well-recognized pharmacoepial drug plants which may prove difficult to grow in India.

India being a vast country with a wide range of soil and climatic conditions, a large number of drug plants grow wild and others can be cultivated in localities most suitable for their growth. The collection of wild drug plants has certain disadvantages from the commerical point of view, and it is often more profitable to bring the more important plants into cultivation. In this connection it may be pointed out that as a first preliminary it is necessary to obtain accurate knowledge of the climatic and other conditions under which a plant would grow best, before undertaking its cultivation. It would be convenient if small areas were taken as the units of study and detailed observations were made on the time of flowering, fruiting, seed-setting, maturity and methods of propagation, etc., of the more important medicinal plants. It is hoped the information given below on the wild medicinal plants of Delhi Province will be useful in this respect.

Kirtikar and Basu [1938] described 1381 medicinal plants from the whole of India, out of which about 350 are cultivated. Of the remaining 1000 plants or so nearly 250 are met with as wild plants in the small province of Delhi. Again Chopra [1933] has given a glossary of 2200 medicinal plants growing in India, both wild as well as cultivated. About 350 plants from his list are found in Delhi, over 90 per cent being wild. Some of these are abundant while others are scarce.

The more important plants are described immediately below. The notes regarding the uses of the plants are based on the two references cited above and upon information collected locally.

Argemone mexicana L. (Papaveraceae); Mexican poppy—vern., *kandiari*. An erect, annual herb common in waste places. Leaves spiny-toothed flowers yellow; fruit a prickly capsule containing black globose seeds. Flowers in winter, seeds ripening in April-May. The yellow latex is used in dropsy and jaundice. It is also used by local *vaids* in the preparation of certain ointments. The seeds yield about 22 per cent of argemone oil used in the treatment of ulcers. The oil contains small quantities of berberine.

Aristolochia bracteata Retz. (Aristolochiaceae) —vern., *kiramar*. A slender, prostrate, perennial herb with glaucous leaves. The perianth is very characteristic in having a sub-globose base, cylindrical tube and a trumpet shaped dark purple mouth. The fruit is a 12-ribbed glabrous capsule about 1-1½ in. long. Flowers over the greater part of the year. It is an extremely bitter plant and is used as an anthelmintic. The roots are said to be used as a substitute for ergot. It is also reputed to be an antidote to snake poison.

Achyranthes aspera L. (Amarantaceae)—vern., *chirchitta*. A common weed of waste places, characterized by long rigid spikes and inconspicuous flowers with spinescent bracts and bracteoles. Flowers almost throughout the year. Flowering spikes and seeds are used for snake bite. A decoction of the whole plant is given in renal dropsy.

Acacia arabica. Willd. (Mimosoidae)—vern., *babul, kikar*. A moderate-sized evergreen spinescent tree. Leaflets 10-20 pairs, flowers in yellow globose heads. Fruit a 3-6 in. long beaded pod. Flowers during the rains and winter. Pods ripen in March-April. The bark is an excellent astringent and is used in chronic diarrhoea. Its chief uses are as an astringent douche in leucorrhoea and vaginal discharges, as an enema in piles, and as a mouth-wash.

Artemisia scoparia Waldst, and Kite. (Compositae). A perennial herb 3-6 ft. high; stem tinged with purple; leaves pinnatisect with linear segments; flower-heads yellow. It grows in dry, sandy places and flowers after the rains.

As several other species of *Artemisia* contain the drug santonin, it is quite possible that this species may also possess it. It is used as a purgative.

Boerhaavia diffusa L. (Nyctaginaceae). A very common prostrate herb with thick, glabrous, unequal leaves. Flowers pink, arranged in small umbels. It grows well in dry places and flowers practically throughout the year.

It contains the alkaloid punarnavine, an injection of which increases blood pressure; also used in anaemia and heart diseases. The plant contains appreciable quantities of postassium nitrate.

Butea monosperma (Lam.) Kuntze; syn. *B. frondosa* Koen. ex Roxb. (Papilionatae)—vern., *palas, dhak*. A medium-sized tree growing on the ridge. It comes into flower in March and April, when it presents a strikingly beautiful appearance on account of its handsome orange flowers. Pods are 4-8 in. long and are very velvety.

It is a useful tree because (*a*) its gum is used as an astringent, (*b*) the flowers and leaves are astringent, diuretic and aphrodisiac, and (*c*) the powdered seeds are used as an anthelmintic.

Balanites aegyptiaca Delile (Simarubeae)—vern., *hingot*. A shrub or small spiny tree, common on the northern ridge; flowers greenish white; fruits about 2 in. long with a hard rind and pulpy inside. Flowers in April-May.

The fruits possess purgative anthelmintic and expectorant properties; also used in cases of snake bite. The active principle is saponin.

Chenopodium ambrosoides L. (Chenopodiaceae). An annual or perennial foetid herb growing in moist places, flowering throughout the year. The well known oil of chenopodium, used in the treatment of round worms, is derived from this plant. It is not definitely known, but appears worth testing if the local variety can be profitably used for the extraction of the oil. The pre-war price of the oil was Rs. 32 a lb.

Citrullus colocynthis Schrad. (Cucurbitaceae); colocynth—vern., *indrayan, kaurtumba*. A perennial trailing herb common in sandy tracts near Nangloi and Narela. The plant resembles *C. vulgaris* (water-melon) except in the fruit which is small, up to 3 in. in diameter, and very bitter (the bitter substance is colocynthin). It is a drastic purgative and in the form of solid extract enters into many of the purgative pills of modern pharmacy. There is a good demand for the pulp of the fruits.

Cleome riscosa L. (Capparidaceae)—vern., *hulhul*. An annual herb growing very plentifully during the rainy season in waste places, especially in rocky situations; leaves 3-5 foliate; flowers yellow; capsule 2-3 in. long; seeds black.

The juice of the leaves mixed with warm *ghee* is used in earache. The seeds are more important, being efficacious as an anthelmintic and as a counter-irritant in chronic painful joints. The seeds are sold at twelve annas a seer in the bazaars of Delhi.

Corchorus antichorus Roeusch. (Tiliaceae)—vern., *boh-phali*. A prostrate, much branched, perennial herb with woody stems; flowers yellow; capsule cylindric, about $\frac{1}{2}$ in. long. It is common in waste places and new shoots come up in the rainy season.

The whole plant is locally used in the treatment of gonorrhoea. In the bazaars of Delhi, especially in the Chandni Chowk old women bring locally collected basketfuls of this herb, for sale.

Cissampelos pareira L. (Menispermaceae)—vern., *Nirbsi*. A twining shrub common in the gardens on the Rohtak Road. Leaves are orbicular in shape; fruits are small, subglobose, scarlet when ripe. Flowers during the rainy season.

The dried root of the plant is a common bazaar drug. A decoction of the root is used as a diuretic and also in bowel complaints. Leaves are used in sores and itches. Three alkaloids, *viz.* sepeerine, bebeerine and cissampeline, have been shown by analysis to be present.

Fumaria parviflora Lamk. (Fumariaceae)—vern., *pitpapada* or *papra*. An annual often scandent herb with much divided leaves; flowers purplish in leaf opposed racemes; fruits small, globose. It is abundant in cultivated fields as well as waste places, flowering during winter. It contains the alkaloid fumarine.

A decoction of the plant which is very bitter is locally used for blood purification. In this respect it is used as a substitute for *Swertia chireta* (*chiraita*) which grows chiefly in the hills.

Adhatoda vasica Nees. (Acanthaceae)—vern., *arusa, basuti*. An evergreen shrub 4-8 ft. high. Flowers white, in dense spikes 2-4 in. long; capsule 1 in. or more in length. The plant is common throughout the province.

The active principle is an alkaloid called vasicine found in the leaves. The fluid extract prepared from the leaves relieves cough and liquifies sputum.

Lippia nodiflora Rich. (Verbenaceae). A widely creeping, much branched perennial herb. Flowers sessile, white or pinkish, arranged in dense globose to oblong spikes. It is very common in the *Khadar* tract. It is often seen in the grassy lawns of Delhi irrigated with river water.

The plant is used as a febrifuge and as a diuretic. Local people use the flowering and fruiting spikes in treatment of small pox.

Polygala chinensis L. (Polygaleae). An erect or diffuse annual 6-12 in. high with narrow linear leaves; flowers light purple. Common in light soils and flowers for the greater part of the year.

It is a good substitute for *Polygala senega*, an American plant. It contains senegins resembling

saponin. Preparations of this plant are used in chronic bronchitis.

Sida cordifolia L. (Malvaceae)—vern., *bijband.* A small erect shrub with cordate leaves; flowers small, yellow. It is a common weed, flowering during the rains and the cold season.

It is considered to be one of the most valuable drugs in Ayurvedic medicine. The plant contains small quantities of ephedrine hence its use as a cardiac stimulant. The seeds are used in leucorrhoea, spermatorrhoea and gonorrhoea.

Sisymbrium irio L. (Cruciferae)—vern., *khubkalan.* An erect annual, 1-3 ft. high, common everywhere as a weed of the cold season. The seeds ripen in March; they are small, roundish, yellow to brown in colour.

The seeds are expectorant, stimulant and restorative, and are used frequently in asthma. In the Delhi bazaars, seeds are sold at the rate of 8 to 12 annas a seer. The seeds of an allied species, *S. sophia* L., are also used as a substitute for the above.

Solanum xanthocarpum Schrad. (Solanaceae)—vern., *kateli.* A prostrate perennial herb with prickles all over the plant; flowers bluish purple, in small cymes; fruits small, yellow when ripe, ½-¾ in. in diameter. It is quite common in waste places, flowering and fruiting almost all the year round.

Its chief uses are as a cardiac tonic and as a carminative. It is also useful in asthma. Locally the fruits are applied, after crushing, on sores.

Urginea indica Kunth. (Liliaceae); Indian squill—vern., *Jangli piyaz.* A herb with tunicate bulbs; leaves radicle, linear; flowers drooping, arranged distantly on a long leafless scape, often appearing before the leaves. Bulbs are 2-3 in. long. It grows commonly on the northern ridge, almost amongst the stones. The flowering scapes appear in March-April.

The Indian squill has been found to be in no way inferior to the imported varieties of *Urginia scilla* and *U. maritima.* The bulbs possess cardiac stimulant and diuretic properties.

Vitex negundo L. (Verbenaceae)—vern., *sambhalu.* A tall shrub with thin gray bark; leaves 3-5 foliate. Flowers blue, in cymes, forming terminal panicles. It grows commonly in the *bangar* tract on the raised bunds along the unmetalled roads. Flowers over the greater part of the year.

It is a common bazaar drug. The heated leaves are applied to painful and rheumatic swellings. Macerated leaves, made into a paste, are given as a cooling application on the forehead in headache.

Vitis trifolia L. (Ampelideae)—vern., *nirbsi.* A slender climber with 3-foliate leaves; leaflets 1-3 in. long, ovate-lanceolate, dentate; cymes axillary, 3-5 rayed with many cymose branches; flowers greenish white; fruit a small globose berry. New branches appear after the first shower in the rainy season. Fruits ripen in September-October.

The tuberous roots are locally used in the case of snake bites. The leaves are often used in the form of a poultice in the treatment of boils.

In addition to the above there are a number of other plants some of which are common bazaar drugs and others are important because they contain important active principles. These are listed below: *Acalypha indica* L., *Anagallis arvensis* L., *Asphodelus tenuifolius* Cavan., *Alhagi camelorum* Fisch., *Ailanthus excelsa* Roxb., *Coldenia procumbens* L., *Cannabis sativa* L., *Cressa cretica* L., *Cassia occidentalis* L., *Cassia obtusifolia* L., *Calotropis procera* R. Br., *Cardiospermum helicacabum* L., *Cocculus villosus* Dc., *Datura fastuosa* Nees., *Euphorbia hirta*, *Gynandropsis pentaphylla* Dc., *Hygrophila spinosa* T. And., *Lochnera pusilla K. Schum*, *Oldenlandia corymbosa* L., *Trichodesma indicum* Br., *Verbascum thapsus* L., *Volutarella divaricata* Benth., *Withania somnifera* Dunal, *Xanthium strumarium* L.

Fresh branches with flowers and young fruits attached of a number of wild plants are sold in Delhi for medicinal purposes. Small shops dealing with such plants are attached to some of the important *Unani Dawakhanas.* The more common plants of this nature are listed in Table III. It may be mentioned here that there is only a limited demand for these plants in this form.

Ornamental Plants

Gardens in India are not, as a rule, noted for the variety of herbs and shrubs grown and it is hoped that the notes given below will be of use to those garden-lovers who are interested in out-of-the

Table III

Wild plants sold for medicinal purposes

Name adopted by salesmen	Botanical name	Price per seer of the branches (in annas)
Amarbel	*Cascuta reflexa* Roxb.	4
Aksand	*Withania somnifera* Dunal.	2
Bardang	*Plantago major* L.	4
Barahmi	*Hydrocotyle asiatica* L.	6
Basuti	*Adhatoda vasica* Nees.	2
Bathua	*Chenopodium album* L.	2
Bakanbuti or *Jalbuti*	*Lippia nodiflora* Rich.	2
Jalbhangra	*Eclipta alba* Hassk.	6
Jawasa	*Alhagi camelorum* Fisch.	3
Jal lep	*Herpestis Monnieria* H. B. & K.	6
Kendu	*Diospyros cordifolia* Roxb.	2
Machhechhi	*Polygonum plebejum* L.	8
Makoh	*Solanum nigrum* L.	2
Panakchun	*Heliotropium strigosum* Willd.	4

ordinary things and are prepared to do a little experimenting with new plants. For the sake of convenience the ornamental plants have been divided roughly into four groups according to the seasons in which they flower; winter plants (November to February); spring plants (March-April, although real spring is of very short duration); hot weather plants (May-July); rainy season plants (August-October).

Winter plants

Angallis arvensis L. (Primulaceae). An Annual, procumbent herb, 6-12 in. tall, with opposite-decussate leaves. Flowers bright blue, arranged on erect, opposite, axillary peduncles.

Bidens pilosa L. Compositae. An erect annual, 1-3 ft. tall, with trifoliate leaves. Ray florets are white and disc florets yellow.

Crotalaria sericea Retz. (Papilionatae). An erect, annual or perennial, robust, undershrub, 3-5 ft. high. Flowers yellow tinged with purple, large, arranged in branching terminal racemes. Flowers throughout the year in moist situations.

Celsia coromandeliana Vahl. (Scrophulariaceae). An annual herb 1-3 ft. high, with leaves of different shapes on the same plant. Flowers yellow, in simple or branched terminal racemes, often forming a large terminal panicle. The plant is beautiful when in full bloom.

Ranunculus sceleratus L. (Ranunculaceae). An erect annual, common near water. Flowers yellow in oblong heads. It is common at Okhla.

Saponaria vaccaria L. (Caryophyllaceae). It is already a garden plant and is quite common in the fields in this area.

Silene conoidea L. (Caryophyllaceae). An erect dichotomously branched annual, 6-18 in. high. The flowers which have an elongated, inflated calyx tube and cross-shaped pink petal lobes look quite handsome.

Verbascum thapsus L. (Scrophulariaceae). The plant resembles tobacco in the vegetative stage. Spikes up to 2 ft. long. Flowers yellow, much crowded, giving the spikes a cylindrical appearance.

Spring plants

Arnebia hispidissima Dc. (Boraginaceae). A more or less prostrate, hispid herb with bright yellow tubular flowers in compact one-sided scorpioid cymes.

Butea monosperma (Lam.) Kuntze. (Papiloniatae). The Flame of the Forest; a medium-sized tree. Flowers bright orange red, large, in axillary and terminal racemes. The leaves generally appear after the flowering is over.

Capparis aphylla Roth. (Capparidaceae). Red flowers in elongated racemes on leafless branches present a striking sight and are useful for cutting.

Erythraea ramosissima Pers. (Gentianaceae). A small delicate annual, common in moist places and lawns. Flowers pink, arranged in dichotomous cymes. A short-lived plant, 6-10 in. high.

Pulicaria crispa Benth. (Compositae). A perennial much branched herb, 1-2 ft. tall. Heads yellow, solitary. The plant looks beautiful when in full bloom. It does not require much care.

Tecomella undulata Seem. (Bighoniaceae). A medium-sized tree. It is one of the most beautiful ornamental trees when in flower. Flowers orange-yellow, fairly large, in corymbose racemes. Not very common in this area.

Hot weather plants.

Cryptostegia grandiflora Br. (Asclepiadaceae) A large evergreen climbing shrub with thick glossy foliage and large handsome pink, funnel-shaped flowers. Very common at Okhla. It is however not truly wild.

Rainy season plants.

Commelina nudiflora L. (Commelinaceae). A diffuse annual herb with prostrate or sub-scandent branches; leaves lanceolate; cymes enclosed in spathaceous bracts, flowers blue.

Ipomea hederacea Jacq. (Convolvulaceae)—vern., *nilkalmi*. An annual twining herb with trilobed leaves. Flowers blue, funnel-shaped, quite pretty, appearing in August-September.

Lantana indica Roxb. (Verbenaceae). A tall shrub with straggling branches. Flowers white, arranged in axillary heads or spikes.

Leucas aspera Spreng. (Labiateae). An annual 6-18 in. high. Flowers white, sessile, in terminal and axillary distant whorls up to 1 in. in diameter. The globular flowering heads are rather attractive.

Rivea hypocrateriformis Chois. (Convolvulaceae). A large climbing shrub with white, clove-scented flowers. Common near the 'Malcha View' on the ridge.

Ruellia prostrate Lamk. (Acanthaceae). Commonly found in moist and shady places amongst the bushes. Flowers bluish purple, funnel-shaped.

Vicoa vestita Benth. (Compositeae). A much branched, fairly tall, annual herb with bright yellow flowers in discoid heads.

Material for Plant Breeding Work

There was a time when wild plants were considered to be of interest to the taxonomist only, and plant breeders limited their breeding experiments to the existing cultivated varieties. After a time, however, it became apparent that, in the case of many crops, the limit of improvement

on this basis had been reached and it was necessary to discover or introduce new genes and to devise new ways of combining them with the old genes. It is now known that many wild or little-known species or varieties related to our cultivated plants exist and it not infrequently happens that these are resistant or immune to some of the diseases that exact such a heavy toll from their cultivated relatives. Sometimes they are able, again unlike the cultivated varieties, to thrive under conditions of severe cold, heat or drought. Modern plant breeders therefore are keenly interested in wild forms and the possibility of transferring valuable genes from these to the cultivated varieties, and numerous expeditions have been organized within the last two decades or so to search for new genes. Outstanding leadership in this direction has been shown by Dr. Vavilov of Russia. The use of wild plants in breeding has also received stimulus from the discovery that by the use of colchicine chromosome numbers can be doubled, leading to the consequence that sterile hybrids resulting from wide crosses can be made fertile.

The plants described below appear to merit the attention of the plant breeder. It is hardly necessary to point out that plants which flourish in the dry scrubby portions of Delhi Province, especially the exposed portions of the ridge, possess in abundance drought resistance and hardiness.

Carthamus oxyacantha Bieb., wild safflower—vern., *Poli, Kasumbhi.* Although low in oil content, it is exceedingly hardy and drought-resistant. It is also somewhat resistant to *Acanthiophilus helianthi,* an insect which causes great damage to the flower heads of the cultivated safflower (*Carthamus tinctorius*). By suitable hybridization it may be possible to combine this resistance with high oil content. It is a very common weed in *rabi* crops.

Hibiscus micranthus L. (Malvaceae). A fibre plant commonly growing as a perennial shrub on the ridge almost amidst the stones. The plant grows quite tall. It may be worthwhile exploiting this plant from the fibre point of view. It has also been observed that it is not as highly susceptible to frost as *H. cannabinus* and *H. Sabdariffa.*

Corchorus spp. (Tiliaceae). Several species of *Corchorus* allied to *C. capsularis* (the jute plant), *viz., C. olitorius, C. trilocularis, C. acutangulus* and *C. antichorus* grow in a wild state. Delhi soil is apparently very well suited for *C. olitorius,* certain varieties of which are culivated for fibre chiefly in Bengal. It would be worth investigating if any of the above species could be made use of in the improvement of the jute plant.

Crotalaria spp. (Papilionatae). *C. sericea, C. burhia, C. mysorensis* and *C. medicaginea* are a *few* wild species met with in this tract: the former two are perennials and the latter two are rainy season annuals. The following points require investigation with regard to the above species:

1. Whether the leaf size of *C. sericea* could be introduced in to *C. juncea,* with a view to producing a better fodder and green-manuring plant. Attempts at crossing these species have so far been unsuccessful.
2. What is the green manuring value of these species as compared to the common sunn-hemp.
3. Breeding of an early maturing *C. juncea* by making use of *C. mysorensis* which is an early maturing species.

From the fibre point of view all these species seem to be undesirable on account of their branching at low heights.

Plantago spp. (Plantaginaceae). Several species of *Plantago viz. P. ovata* (*isaphgol*), *P. amplexicaulis, P. pumila* and *P. major* grow in a wild state.

Although locally no use is made of these plants the fact that *P. ovata* grows wild indicates the suitability of this tract for its cultivation. It is an important drug plant, the seeds of which are used in the treatment of a number of diseases, specially dysentry. The possibility of utilizing the species other than *P. ovata,* directly or indirectly in the improvement of *P. ovata* or *P. psyllium* (B.P. Plant) is worth investigating. *P. ovata* and *P. major* are generally found in moist situations whereas *P. amplexicanlis* and *P. pumila* are generally found in dry, rocky places.

Nicotiana plumbaginifolia Viv. (Solanaceae). An annual herb common at Okhla and near the Jumna bridge. It is apparently resistant to virus but contains only negligible quantities of nicotine. Its seeds can be collected in May.

Solanum incanum L. (Solanaceae). A perennial shrub much resembling the egg-plant. *S. melongena* L. It has small round bitter fruits about 1 in. in diameter; flowers and fruits appearing in the rainy season. It is fairly resistant to drought and the shoot borers. It may be useful in the improvement of the egg-plant since it crosses easily with it when the egg-plant is used as the male parent. The bitterness of the fruit is dominant in the F1. By suitable crossing it should be possible to isolate a plant free from bitterness.

Lolium temulentum L. (Gramineae). The genus *Lolium* is allied to *Triticum* and *Hordeum. Lolium temulentum* is rust and possibly smut resistant, but not resistant to drought. It has a high tillering capacity and produces a fairly large number of grains per plant as compared to wheat and barley. Although past attempts

at crossing this with wheat have not been successful, it is possible that systematic cyclic crossing with wild and cultivated wheats and barleys with different chromosome numbers may lead to success.

Urena lobata L. (Malvaceae); Aramina. It occurs as a perennial weed and a number of plants can be seen in waste places along the Shahdra Road. It furnishes a yellowish white fibre that is said to be more lasting than jute and as such is used as a substitute in many industries. It is grown commercially in Cuba, Madagascar and Brazil where it is chiefly used in making coffee sacks. It is worthwhile experimenting with the quality and economics of the local variety from the fibre point of view.

Other useful plants

Cryptostegia grandiflora R. Br. (Asclepiadaceae). In the present war it has received attention as a possible war-time source of vegetable rubber. At Okhla on the right bank of the river there is a strip about $1\frac{1}{2}$ miles long and a furlong wide having big bushes of this plant said to be more than 25 years old.

Vetiveria Zizanioides Nash. (Gramineae). A perennial grass much resembling the wild *saccharum* (*S. spontaneum*) in the vegetative stage. The roots and rhizomes of this plant yield oil of vetiver, much used in perfumery. It is not very common but it can be grown very easily for commercial purposes.

Sapium sebiferum Roxb. (Euphorbiaceae); Chinese-Tallow tree. A medium-sized tree superficially resembling *Dalbergia sissoo*. A number of trees of the species can be seen in the Subzimandi gardens, and probably it is a moisture-loving plant. The seeds yield a drying oil which is in great demand. The thick layer of hard white fat on the seeds of this plant is the source of Chinese vegetable tallow.

Bombax malabaricum DC. (Bombacaceae); *semal*, and *Calotropis procera* Br., Asclepiadaceae; *akha*, yield silk cotton which is the best material for stuffing pillows etc. The mature woolly spikes of *Aerua tomantosa* Forsk. (Amarantaceae) can also be used for the same purpose.

Typha angustata Chaub. and Bory. (Typhaceae)—*patera*. It grows abundantly in ditches near Okhla. The leaves are used for thatching and for making mats. A poor quality rope is also made out of the leaves.

Tamarix dioica Roxb. (Tamaricaceae)—vern., *jhau*. A shrub with long spreading or drooping branches. It is very common in this area especially in river beds and waste alkaline places. The branches are used for making brooms and baskets. Every year there is a regular auction of these *jhau* thickets.

Desmostachya bipinnata Sta.–*Eragrostis cynosuroides* Retz. (Gramineae):—vern., *dhab*. The culms make a broom which in the opinion of the local sweepers lasts twice as long as the brooms generally used in the houses.

Saccharum spontaneum L. (Gramineae); wild Saccharum —vern., *kana, sarkanda*. The culms are extensively used for making 'chicks'. Entire plants are used for thatching purposes. Very common all over the province.

Xanthium strumarium L. (Compositeae). A fairly tall, scabrid, annual, growing in low-lying places where there is accumulation of water. Fruits have short tubercles and as such the plant is considered to be a harmful weed on account of its fruits sticking to the wool of the grazing sheep. Recently it has been found by Russian workers to be a new oil plant with commercial possibilities. The seeds yield 34 per cent oil. The oil has high specific gravity and resembles linseed oil as regards iodine number; its saponification value is also high. In all these points it takes priority over sunflower and castor oils. The plant is quite common in this area.

Summary

About one hundred and fifty important wild plants of the Delhi Province have been classified according to their uses, under six heads, *viz.* (1) edible plants, (2) fodder plants with special reference to famine conditions, (3) medicinal plants, (4) ornamental plants, (5) material for plant breeding work, and (6) other useful plants. A brief botanical description of each plant and common English and vernacular names and places of common occurrence within the province of the more important plants are given. The notes regarding the uses of the plants are based on the references cited in the text and also upon the information collected by the author from the local people while surveying the area for plant collection.

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EVERY FORESTER A TIMBER OWNER.

A Way to Professional Prosperity and Prestige

George Vitas

Consulting forester, Houston, Texas. Junior member, S. A. F.

The author points out that the profession has much to gain through every forester becoming a timberland owner. He rightly points out that the aggregate influence of such ownership would have tremendous weight with all forest landowners and with the public. He believes it would also prove a good investment provided arrangements were worked out for others to take care of properties should the owner be transferred.

This article is not intended to be an attack on private forestry, the public forest services, forestry schools, forestry associations, or anyone else. It is an effort at an honest appraisal of a vital problem. Nothing would suit me better than to see idea that I am proposing, discussed, damned, torn apart, or even praised I don't care what treatment it receives, as long as it generates thought, discussion, or, better still, action. If it serves to launch foresters into thinking about the opportunities that lie at their finger tips I will be content. But I am hoping that it will do more than that. I am trusting that it will encourage every living forester to set up a professional goal for himself—a goal whose ultimate achievement is culminated with personal timberland ownership!

Only One Forester in Twenty Owns Forest Land

The 40th Annual Society Meeting (Washington, D. C., December, 1940) was an illustrious one. It was not a meeting dominated by struggling young foresters. It was a meeting in which seasoned, successful, veteran foresters were in the majority. Many had one, two, and even three decades of proud forest practice under their belts. And yet, out of one session of this meeting came an astounding piece of information.

In the discussion that followed presentation of the paper, "Regulated Forest Managenment in the U. S.," R.W. Graeber* asked this question: "How many in this audience have invested any of their earnings in trees as a crop, other than shade trees around your home?" And, after counting hands, the Journal records Mr. Graeber as saying: "About five percent." *Only five out of every hundred of our nation's most successful foresters had timberland of their own!*

In my effort to dig at the bottom of the reason for this condition, I went through every Journal between the years 1939 to 1946. Nowhere did I find anyone urging foresters to back their faith in their profession by purchasing, on a nation-wide scale, timberland of their own. There were numerous references and "jabs" at foresters and hints that they were theorists because they were not timber owners. But no one advocated the only logical solution to the situation—a well-planned, constructive program to make every forester a timberland owner in 20 years or less. I wish to advocate this program *now*. Did I hear someone say it's a lot of theory. Well, read on.

Is there a forester, government or private, who at one time or many times in his career has not heard this corny song? When aimed at government foresters, it usually goes something like this: "The government doesn't have to pay taxes and worry about profits. Besides, you guys don't personally own timberland, so how can you understand our problem?" Or, when directed at private foresters, the tune might have these lyrics: "Foresters are all alike. They are always talking about managing timberland—somebody else's. If this thing is so good, why don't they go out and buy some of their own and start sweating out taxes, fire losses, insects, and diseases; the timber market, and what not. How can you understand this thing when you don't have any of your *own* money sunk in it?"

I do not agree with the moth-eaten conclusion of the tunes that I mentioned—*i.e.*, "foresters, not being timber owners do not understand the problem of the private owners." I believe that there are numerous instances in which both government and private foresters have proved themselves to be exceedingly well informed on the problems of the timber owner. But as honest foresters, we cannot deny the truth of the other half the tune—the part that goes like this: "Foresters are always talking about managing timberland, *somebody else's timberland*."

For more than 45 years the bulk of the burden of spreading forestry has been carried by the U. S. Forest Service. No matter what we are—executives of lumber and paper concerns, consulting foresters, professors, or government

* Jour. Forestry 39: 242. 1941.

foresters, this fact is indisputable. Because the Forest Service has always been in the spearhead that has been striving relentlessly to bring about better forest practices and because it has had to do this in the face of stiff opposition, and in the face of wars and changing economic conditions, the guns of critics have been trained on it. I believe, that we, as individual foresters, have done very little to carry our just share of the evangelism and dirt forestry that goes with our profession. We have been spectators, watching the game, not playing it! Only by purchasing timberland can we become active participants in the game that we have chosen to be our life's work.

Forests Offer Real Investment Opportunities

I wonder how many foresters realize that no investment—absolutely none—has the sound characteristics of managed timberland ownership. During depressions, idle agricultural lands show little or no earnings. Idle factories suffer with the same result. But if a forester can pay his taxes, keep fire out, and give it the necessary silvicultural attention, his investment is perpetually working for him, earning constantly because a crashing stock market cannot force mother nature to halt the growth of an established timber stand. When normal prosperity returns, the farmer has his land—minus the earnings of those depression years; the manufacturer may or may not have his plant, and in addition, he too is minus depression year earnings. But the timberland owner, he has his timber *plus* the increased value that increment of the depression period has blessed him with! No other investment has these same security characteristics!

As foresters there's no sense in kidding ourselves. The most powerful sales angle in the world today is the "I use it myself" line. In terms of forestry and timberland the translation reads: "I own some myself."

Active participation by foresters in timber ownership and management will do much to bolster them financially and to raise their professional morale. It will assist in commanding the attention and respect of the layman, who today, after more than 45 years of forestry still thinks that a forester is a tree surgeon. When informed that the preparation for the forestry profession entails four years of college education, his amazement becomes indescribable.

A forester, regardless of whether he intends to go into government forestry, game management, research, private forestry, utilization, education, no matter what phase of his profession he is preparing for, should be exposed, while in school, to the potentialities and desirability of owning and managing his own forest land, even though it be but 10 acres. We foresters, have in the past, been needling the layman into practising forestry. We have declared the principles of forestry in hundreds, yes even thousands of bulletins, posters, demonstrations, lectures; but rarely have we been able to say to the timber owner: "Now I own 100 acres of timber of my own. It's located right here in Buckskin County I've had it under management for 9 years; won't you come up and see it."

Obstacles of Transfers Are Surmountable

Just how should foresters go about becoming forest owners? They young forester will probably say, "I don't have the money to buy timberland with." The older forester could add, "I've been moved around so much that I neither have the money not the necessary contacts." Any forester, employed either by the government or industry might exclaim, "I'm employed by this organization, and they might not like the idea of my going out and buying timber for myself."

The solution calls for cooperation and tolerance by both employer and employee. A financially embarrassed forester need not buy 500 acres at the beginning. He could pool his resources with other foresters. Form a corporation. He might for ten dollars buy a share of common stock in a concern organized by foresters, for the purpose of producing and marketing forest products. In like manner partnerships or even cooperatives are possible. We've been hounding the small woodlot owner with the cooperative "angle;" how about trying it ourselves? On the other hand, if the forester has sufficient capital, there is nothing in the world to prevent him from buying parcels of timberland, solely for himself.

For the forester who is moved around a lot, and what forester isn't, there should be little to prevent him from purchasing timberland in any section of the country where he can get a reasonable buy. Arrangements with other foresters in that section or a personal visit will do the trick. Cooperative care of each other's timberland could be worked out by individual sections of the Society. As for those who would cry out that this action is taking the Society into the forestry business, the answer is, "No." The Society is merely the vehicle whereby foresters are able to get together for mutual professional benefit. Any business associations formed as a result of this activity would be purely personal, and would in no way involve the Society. Of course the ideal situation is where a forester can buy timberland in the same section of the country in which he is employed.

Employers Would Benefit

As to the big question—the one of objection from one's employer—I don't think this is as serious as surface appearances indicate. For government-employed foresters there is plenty of precedent:— agricultural extension agents serve the farmer, and, in most cases, own and manage farms of their own without detriment to their jobs. As a matter of fact it is a distinct asset, for they are "practicing what they preach." As for private industry—there should be no objection at all. For the forester would be out to rectify the very thing that private industry has unmercifully held over his head so long—the charge that because a forester does not own timberland of his own—he is a theorist.

After 45 years of professional existence in the U. S. we have missed one of the greatest opportunities ever accorded professional men—the chance to practice what we preach—with our own money. If foresters between 1900 and 1946 had periodically sat down and laid out programs for professional self-betterment, they would to-day be the individual owners of 2,500,000 acres of timberland scattered about in every forested area of the U. S. There would be 3,000 or more model forests owned by individual professional foresters or groups of foresters. These demonstration forests would have done more to establish good forest practices and make the part played by the profession understandable to the layman than 3,000 tons of pamphlets. I am afraid that the men who so proudly and justly take credit for our general professional progress have unfortunately overlooked and failed us in this vital respect.

However, it is not hopeless. It is never too late to start. First we must lay out a program of action. But before we do this we should determine the reason for the failure of our elders to establish themselves in the field of timberland ownership. In my opinion, it drifts back to school. Too many forestry schools are teaching students to manage somebody else's timberland. They are not instilling into their students the desire for personal ownership. Nor are they taking the time to concentrate on the problems involved in managing and owning *small* woodlots. They are developing one-track minds; minds which can think only in terms of managing somebody else's timberland—thousands of acres of it!

There's money in timberland. Most foresters know this, some don't and a few secretly doubt it. Seventy-five percent of the nation's commercial timberland is privately owned. If timberland ownership was the losing proposition that it is painted to be, a vast share of this acreage would have reverted back to public ownership—via the tax delinquency route—long ago. Further, consider the large acquisition program quietly but steadily being conducted, in choice locations, by lumber and paper companies and I am certain that regardless of the familiar chorus of "taxes, losses, and low profits as deterrents to timberland ownership"—there must be money in it! Corporations are created to make profits, not to conduct charitable activities. Figure it out for yourself, forester!

Ownership Begets Confidence

The average American forester today is financially poor. He has absorbed considerable abuse and has laid the foundation for a professional inferiority complex. His faith in his profession is still firm. Like a school teacher, he is intensely loyal to it. But the virile pride and poise of a confident, successful man is not there. That defensive look is stamped on his face.

Nation-wide timberland ownership and management by foresters would bring many desirable results. Foresters would shed that defensive look. When challenged as to their qualifications to advocate good forest practices on private lands, they could point to their ledgers and to their own timberlands. They would have the immense satisfaction of knowing that they are backing their profession with their own money, not because of sentiment, but because they are out to make a profit! Many foresters no longer in the profession, would gather new interest in their old profession and would invest in timberland. This interest and enthusiasm could catch on and spread to the hundreds of timber owners who have had no forest training. Their inquiries would have to be answered. There would be additional jobs for consulting foresters, timber cruisers, timber markers, and others. Add to this the general overall benefits to foresters and the nation's timberlands and the thing begins to get big. There would be working proof that despite taxes, fire, diseases, insects, and the profit and loss sheet forestry is practical.

To-day, there are approximately 12,500 living graduate foresters in the U. S. Let's completely forget about the 15,000 new foresters who will be graduated in the next 20 years. If in the next 20 years, each of to-day's 12,500 foresters acquired an average of 200 acres, 2,500,000 acres of the country's timberland would be under the *ownership and management of foresters.* Allowing for the fact that many of these foresters would be joined together in corporations, partnerships, or cooperatives, we can assume that approximately 3,000 model forests could be established by foresters in every timbered portion of our country. These forests would receive the best possible management and accurate books

should be kept of costs, losses, profits. There should be an end to the familiar old refrain: "If you owned timberland of your own..."

I believe that foresters can carry out this program without detriment to their present jobs. As a matter of fact, they should become greater assets to their employers, be it the government or industry.

Plan Now—Buy Later

In conclusion, I wish to make this comment. It is unfortunate that our economy, at present, is so inflationary. It would be unwise to purchase timberland at the exorbitant prices charged to-day. However, sometime in the near future, business will reach a normal state again. Then, or better yet during depressions, foresters should embark upon a dynamic program of making themselves timber owners—of backing their faith in their profession with their own "cold cash." This does not mean that in the meanwhile nothing should be done. Much can be accomplished between now and then. Foresters should get together in sectional meetings or in small personal groups, discuss their prospects and make plans. They should be on the lookout for likely parcels of timberland. Right now they can go so far as to start a timberland purchase fund for the time when timber will be available at reasonable prices again. If there was sufficient interest, a national committee of the Society could maintain an account of the progress being made by the various Sections.

Think it over, forester. Are you going to continue to cringe and gulp every time you hear this record played: "Foresters are always talking about managing timberland—somebody else's timberland." Or, are you going to take up the challenge?

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THE INFLUENCE OF MAN ON MARINE LIFE.

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Man's direct influence on marine life is of comparatively recent origin, for until about two hundred years ago the amount of fishing and whaling that was carried on was too small to upset the equilibrium of nature. With improved ships, apparatus, and technique, however, came a vast and indiscriminate slaughter of marine life, and some species were exterminated altogether. There is now a general realization that wise cultivation of the sea is as necessary as wise cultivation of the land Professor Yonge gives a broad survey of the problem.

Man has had a profound effect on terrestrial life. Hunting, first with flint tools and eventually with precise weapons, led to the extinction, for instance, of the bear, wolf, and boar in Britain and to the almost complete extinction of the bison of North America. Like the big game of Africa, this animal has been saved only by tardy methods of conservation. Fur-bearing animals have been remorselessly trapped. The faunae of the earth have been irreparably impoverished by the senseless destruction of unique birds such as the dodo and the great auk. Cultivation of crops and domestication of animals modified plants and animals so greatly that the exact origin of some is now obscure, and also effected far-reaching changes in the balance of nature. The greater the crops, the more the pests—insects, rodents, and birds especially—that were attracted.

With the full discovery of the world by western man, his crops and domestic animals were introduced into the new lands of America, Africa, and Australasia, and many of the foreign plants were brought back—accompanied all too frequently by foreign pests. Often for sentimental reasons, hosts of other plants and animals were similarly transported. This indiscriminate mixing of fauna and of floraled to disasters such as the plague of rabbits and prickly pear in Australia, and that of bramble thickets spread by the introduction of the starling into New Zealand. Man, in despair, turned to nature to redress the balance he had wantonly destroyed, and, after some failures, there were developed methods of biological control which to-day are clearing the prickly pear from Australia and destroying the aphid pests of Californian orchards. But, despite the rigorous care enforced by bitter experience, the spread of life continues. The chance introduction of a malaria-carrying mosquito, *Anopheles gambiae*, from West Africa into Brazil in 1930 caused a terrible epidemic, overcome only after heroic measures by the Rockefeller Foundation.

Life in the sea has been much less affected by man. In the obscurity of its depths and in the breadth of its oceans animals are difficult to hunt to extinction, while most of the marine vegetation and the bulk of the diverse invertebrate fauna are useless to man. In the sea, it

has been said, man reaps without sowing, and this is largely true. It follows that in this case the responsibility of ownership which came with the domestication of animals and the care of crops has rarely displaced the unconsidered greed of the hunter. This is nowhere better shown than in man's pursuit of the marine mammals.

There are three groups of these: the sirenia or sea cows, the marine carnivora such as seals and walruses, and the cetacea comprising the whales, dolphins, and porpoises. The sirenia are a small group of obscure origin and grotesque form. They inhabit inshore and estuarine waters, feeding on marine vegetation. They consisted, until recently, of three groups, the Indo-Pacific dugong, the manatee of the tropical Atlantic, and the much larger northern sea cow of the North Pacific. The first two survive, although actively hunted—fortunately mainly by native tribes—for their flesh and blubber. The sea cow became extinct some thirty years after its discovery in 1741 by the young German naturalist Georg Steller, who accompanied Behring's pioneer voyage to the North Pacific. Under the greatest difficulties, while marooned with unwilling helpers on Behring Island, he dissected and described the animal. The Russian hunters and traders who followed Behring quickly exterminated it, and, apart from Steller's description, there remain for study only a few skeletons. The destruction of the sea cow is the greatest blow yet dealt by man to the marine fauna, equivalent to that of the equally remarkable, harmless, and locally distributed dodo.

The walrus once occurred in vast numbers throughout the north Pacific and the Atlantic, where it extended as far south as Nova Scotia and occasionally reached the shores of Britain. Following wholesale slaughter, such as that of 900 in one day near Spitsbergen in 1852 and that indicated by an annual import of 12,000 tusks into San Francisco alone between 1870 and 1880, it has become restricted to far northern waters. Many seals have suffered similar destruction, in particular those that breed in rookeries, like the Atlantic grey seal, and also the Greenland seal, which is the most important animal in the Newfoundland seal fishery, and the immense elephant seals. Of these, the Californian species is now rare, but the naturalists of the *Discovery* Expedition found that the Antractic species, which had been hunted on such a scale that it was reported virtually extinct a century ago, has reached a population of some 100,000 around South Georgia, where hunting is now annually confined to definite regions of the coast. A warm-water seal, once widely hunted in the West Indies, is now extremely rare.

These animals are sought for their blubber and flesh, but the eared seals, or sea lions, include the fur seals as much prized for their pelts as are sable, beaver, or silver fox on land. Formerly, various species abounded in northern and southern waters, but in the latter they have been almost exterminated, although there is some hope that they may be re-established in South Georgia. The greatest fishery of all was on the Pribilov Islands in the Behring Sea, some three hundred miles from Alaska. These islands were discovered by the Russians in 1786. There the vast rookery, with each huge bull gathering a harem sometimes exceeding one hundred females, and continuously fighting intruding males, must have presented an amazing spectacle. At the hands of Russian and American sealers upwards of two million seals were killed in fifty years. When the United States acquired the islands in 1867, attempts to control pelagic (open water) sealing in the Behring Sea led to international complications, and so to arbitration by a tribunal in Paris. This was followed by two Anglo-American commissions sent to the Pribilov Islands in 1891 and 1896-7. Eventually, pelagic sealing was prohibited by international agreement, and killing on the islands was restricted to the needs for food of the local population. Gradually the seal population recovered, and by confining hunting to the males, one bull to forty bearing cows being adequate for breeding, a rational conrtol has been achieved.

It was the Russians also who discovered the delightful sea otter on the coast of Siberia. This rarest and most valuable of fur-bearing animals was hunted ruthlessly from there across the Aleutian Islands and south to California, where British and American hunters were at work. Almost complete extinction was again followed by international protection early in this century. Subsequent recovery has been slow, but populations of some two thousand in northern regions, and two hundred in southern, were estimated in 1939.

Helpless exposure on or near land invited slaughter of sea cows, seals, and sea otters. A similar fate has befallen the cetaceans, which include the largest animals ever to be evolved—the blue and fin whales—and which are so superbly adapted for aquatic life that they are even born in the sea. The tragic story of their ruthless hunting by man, which was begun by the Basques in the tenth century and has culminated in mass destruction by whale chasers operating from great factory ships in the Antarctic, has recently been related in ENDEAVOUR* and need not be retold.

*L. Harrison Matthews, *Endeavour,* July 1946, p. 116.

Man the hunter has thus inflicted terrible loss on the marine mammals; fortunately it has not been worth his while, except in the one instance of the sea cow, to hunt them to final extinction. He has also, with the elaboration of increasingly efficient instruments of capture, made grave inroads into the stock of many of the more important food fishes. Here attention must be confined to the history of the European fishing grounds, in the exploitation of which Britain has played a leading part. The growth of the modern trawling industry dates from that of big industrial towns and the establishment of rapid transport between them and the fishing ports. The first North Sea trawlers came from Brixham in Devon. Originally in open boats, and later in two-masted smacks, the fishermen gradually extended their activities as far as the Dogger Bank. Towards the end of the last century steam trawlers employing the highly efficient otter trawl began to replace the sailing vessels, and to range as far north as the Barents Sea and as far south as Morocco. This wider range was necessary because the fish become increasingly fewer and smaller on the original grounds. Evidence of overfishing was given before a series of royal commissions but no action was taken, the extension of fishing to new areas tending to obscure the effects of depletion. Then came the war of 1914-18, which imposed a close season on fishing. The result after the war was striking: fish had increased in both numbers and size. In the period between the wars much of the scientific activity of the Ministry of Fisheries was devoted to working out and testing possible remedies for overfishing. This was the more necessary because as the years passed the effects of overfishing again became obvious. To take but one example of many cited by Dr. E. S. Russell in his book *The Overfishing Problem*: the landings of haddock per day's fishing by English steam trawlers in the North Sea were 7.8 cwt. in 1906; this fell to 4.6 cwt. in 1914, rose to 15.8 in 1919, and had descended again to only 2.6 cwt. in 1937 (figure 6).

One obvious method of control is to enlarge the mesh of the vast trawl nets which annually sweep over practically the entire productive surface of the fishing grounds. This would enable the smaller fish to escape for further growth, and possibly reproduction, before capture. Another, more far-reaching, measure is to limit fishing. This demands a wide knowledge of the natural reproductivity of the fish. Unlike the marine mammals, with their annual or biennial production of one calf, fish produce vast numbers of eggs annually, of which only a reach maturity. Food, though abundant, is not infinite, and growth is checked owing to intense competition. In other works, a certain degree of fishing is definitely helpful. It reduces competition and enables more fish to attain a large size. But clearly too intensive has the reverse effect. It is a question of knowing exactly how much can be taken out with safety, so that man may obtain a rich harvest without adversely affecting natural stocks. It is actually not only more economical to fish with fewer vessels but the yield may in fact be greater than if too many are employed and the effects of overfishing produced.

Despite the size and obscurity of the fishing grounds, the basic facts concerning the productivity of the chief north Atlantic food fishes are known. This is due to the labours of the scientific staffs of the English and Scottish fishery services and those of the other maritime countries of western Europe. All normally work in close cooperation through the International Council for the Exploration of the Sea. It is now possible to formulate measures of control, which, when aided by continuous scientific supervision, will permit a rational exploitation of the fishing grounds. How successful such action may be is well shown by the result of treaties made between the United States and Canada in 1934 and 1930, and renewed in 1937, for the control of the Pacific halibut fishery, in which both countries are interested. An international fisheries commission was set up, and the fishery, which had undergone catastrophic decline, has recovered to a striking extent after limitation of fishing. In such rapid recovery we see the result of the great fecundity of fish. Populations of whales or seals may take a century to recover fully after too intensive hunting; those of fish will recover in a much shorter time.

Today, after the second close season imposed by war within a generation, there is clearly an opportunity for conserving the now well-stocked fishing grounds of western Europe. The British Government is certainly of this opinion. At its invitation an international overfishing conference was held in London not long after the end of the war. Representatives of all the maritime nations of western Europe except Germany attended, and considered the possibility of agreeing on measures for regulating fishing in the North Sea and adjacent areas. With the needs of starving populations constantly in mind far-reaching decisions could hardly be expected, but agreement was reached on an increase in the size of the mesh of trawl nets and also on size limits for the twelve most important bottom-living food fishes. Limitation of the tonnage of the fishing fleets of the different countries, which was proposed by Great Britain, was not accepted, but the reality of the problem of overfishing was realized to the extent that an advisory committee was appointed to study the matter and

propose suitable regulations for the prevention of over fishing in the North Sea and adjacent areas. There is thus some real grounds for hope that in the future the fisheries of Europe may, like those of the north Pacific, pass from an era of over-reaching greed to one of rational exploitation based on conservation of the stocks.

Aquiculture, or the cultivation of aquatic life, has been conducted on a very limited scale compared with agriculture. With the exception of some cultivation in Japan of seaweeds from which agar is obtained, it is, moreover, restricted to animals. Its greatest, and by no means negligible, triumph has lain in the cultivation of oysters and other bivalves.

The aim of aquiculture is to increase some part of the population, either in numbers or in size of individuals. This may be done by improving their chances of survival, by transplanting them to regions where food is more abundant, or by increasing the fertility of confined waters. Although there is evidence that the Romans practised crude methods of oyster cultivation in Lake Fusaro and elsewhere, modern cultivation may be said to date from the work of Coste on the French oyster beds. These one-time prolific areas became progressively more depleted as a result of increasing demands from the growing industrial cities during the middle of the last century. Coste realized the fundamental fact that the oyster produces immense numbers of free-swimming larvae, but that only a minute fraction of these find the requisite clean, hard surface for settlement when they sink to the bottom. From his suggestions and experiments arose the modern methods of putting out 'collectors,' consisting of half-cylindrical roofing tiles encrusted with lime and sand, in the early summer, when the oysters are ready to spawn. In this way millions of oyster 'spat' find surface for settlement. Coste further realized the need for protection. After some months of growth, the young oysters are flaked off the tiles and transferred to 'ambulances,' where they are protected by wire netting from their numerous enemies such as crabs, starfish, rays, and marine snails. Later still the oysters are laid out on extensive parks, from which intruders are removed at low tide. To-day the vast area of these parks around the shallow, almost land-locked bay of Arcachon, and in other regions of the French coast, are evidence of a flourishing industry. The French also found that oysters would grow and 'fatten' in areas where they will not necessarily breed, and began to transplant oysters into shallow lagoons or 'claires,' particularly around Marennes. In these warm waters the microscopic suspended plant life, or phytoplankton, on which the oysters feed increases rapidly. By such methods a highly organized and immensely productive oyster industry has been built up along the Atlantic coasts of France.

Similar methods involving provision of settling surface, removal of pests, and transplantation to better feeding grounds, have been developed in many other countries, especially the United States. In the Delaware River, for instance, a natural breeding area some distance up the estuary is maintained, and a collecting surface, in this case consisting of masses of clean oyster shells spread loose or in wire-netting bags, is provided. These shells are later dredged up, the young oysters separated, and a proportion laid on planting beds nearer the sea, where they rapidly grow. The beds are regularly swept with wide-spreading cotton tangles in which the invading starfish are collected in millions, while continuous warfare is waged against other pests. The output of this one oyster fishery runs into some four hundred millions annually.

Along stretches of the Atlantic coast the French also cultivate mussels on long fences of piles and wattling driven into the mud flats. This *bouchot* system was introduced by an Irishman named Walton, who was the sole survivor from a small vessel wrecked in 1235 in the Anse de l'Aiguillon. On the muddy shores of this shallow bay, widely exposed at low tide, he is said to have driven stakes for the attachment of roughly woven grass nest in which he hoped to snare sea birds. He soon found that his nets became covered with mussels, which grew much larger than those on the shore and which proved an excellent source of food. He then took to planting stakes with interwoven twigs between them and so established the simple form of cultivation which still persists.

Modern examples of successful cultivation of bivalves include the unique pearl shell farm at Dongonab in the Red Sea, developed by the late Dr. G. Crossland from 1905 until 1923, when a decline in the price of pearl shell caused its abandonment, and the culture pearl industry in Japan. Small beads which form the nucleus of future pearls are enclosed within pieces of the shell-forming tissues of a pearl oyster, and the whole, by a delicate operation, is grafted into the tissues of an intact oyster. A very different animal, the commercial sponge, offers possibilities to the cultivator. It grows attached like a plant, and cuttings may be made which will round off and grow under suitable conditions.

Transplantation of marine animals over great distances raises much greater problems than does that of terrestrial animals. If climate and food are suitable, many domestic and other animals may flourish in the southern hemisphere or in North America as well as, or even better than, they did in their original home in the Old world.

Fresh-water fishes may also be transported successfully, as the teeming populations of trout and other fish introduced into the rivers and lakes of New Zealand bear witness. But with marine fish there is the additional factor of spawning migrations. In general, fish grow on their feeding grounds but then migrate against the prevailing currents to spawning areas characterized by very sharply defined physical and chemical conditions. From these the small, surface-dwelling larvae are carried passively back by the currents to the adult feeding grounds, sometimes by way of 'nursery' areas. Thus, though an adult fish may feed and grow in new surroundings, the whole complex mechanism of spawning migrations is upset, and the animals fail to establish themselves. Attempts to introduce herring into New Zealand waters failed probably for this reason. Altantic salmon, successfully introduced into the rivers, apparently failed to find their way back to the rivers where they must spawn after feeding and growing in the sea.

On the other hand, transplantation over limited distances is possible. Marked places have been transplanted from coastal waters to the rich feeding grounds of the Dogger Bank and have there grown much faster than similar animals on the original grounds. The Dance have successfully transplanted small plaice from the crowded waters of the North Sea to the richer feeding grounds of the Limfjord.

It is also possible to transplant some marine invertebrates which live and spawn in the same place, usually in shallow water. Oysters and other bivalves are normally 'relayed' on a large scale, although attempts to establish lobsters, which have a more complicated life-history, into New Zealand waters have failed. In Great Britain, where the population of 'native' oysters has greatly declined, young or 'seed' oysters have been purchased from France or the United States. Some of those from France have been of the same species as the 'native,' *Ostrea edulis*, but many have been Portuguese oysters, *O. angulata*, which colonized the southern parts of the French Atlantic coast during the past half-century. This oyster grows well on British beds but never spawns, and so can never become established here. It is indeed the spawning temperature, rather than the temperature at which the adult can live, that largely controls the distribution of marine invertebrates. *Ostrea edulis* spawns when the temperature reaches about 15° C, but *O. angulata* does not spawn until 20° C, which is not attained round our coasts. The same difficulty was found when the Japanese oyster, *O. gigas*, was introduced along the Pacific coasts of North America to replace the smaller local species. The temperature is rarely high enough to permit natural spawning, but some success was achieved in the summer months by placing the oysters in floats where the water reached a higher temperature than on the bottom. Later, successful use was made of discoveries by Dr. P. S. Galtsoff of the United States Bureau of Fisheries, who found that oysters will breed at lower temperatures if stimulated by the presence of their own genital products in the water. In Vancouver, the Japanese oyster (figure 2) has been regularly induced to spawn by pouring suspensions of ripe egg and sperm, obtained from the sheds where oysters are opened and canned, over the beds at the height of the summer.

So far as we have discussed it, cultivation in the sea consists of ensuring high survival rate of certain stocks in areas where food is abundant. Increase in available food, as produced on land by the use of fertilizers, is still in the experimental stage in aquiculture. The 'fattening' of oysters in the *claires* at Marennes is due to the enrichment of the water by seepage of nutrient salts from the land, the rich microscopic flora so ensured froming food for the oysters. In limited masses of water, fertilization by addition of nutrient salts containing available nitrogen and phosphorus is feasible, and initial experiments by Norwegian and Danish biologists have revealed significant increases in plant and animal life. Similar experiments, aimed at an eventual enrichment of the local stocks of fish, have been carried out during recent years in small lochs along the west coast of Scotland.

The dispersal of the fauna of the land by the activities of man is in no way paralleled in the sea. Some of the reasons for this, such as the association of breeding migrations in fish with ocean currents, and the influence of temperature on the breeding of many marine animals, have been noted. Nevertheless species have been carried to new areas either deliberately, as in the case of the oysters, or else accidentally. When American oysters were relaid on British beds they were accompanied by the slipper limpet, *Crepidula*. This was first noted in the eighties of last century and now extends from the Humber round the south coast as far as Dorset. Unlike the species of oyster which it accompanied here, it is able to breed within the range of temperature found around our coasts and has firmly established itself. It is now a major pest on many British oyster beds. Some twenty years ago it was found on the coasts of Holland, where it had apparently been transported across the North Sea attached to floating wreckage or possibly seaweed. Within ten years it had become a serious pest there also, and had also spread north to the coasts of Germany and Denmark. During the hard years of the recent

war the Dutch were driven to utilize this previously unwelcome visitor as a source of human food.

There remain to be mentioned the effects of major engineering works on marine life. The author was first struck by these during a visit to the Carnegie Marine Biological Laboratory on the Tortugas Islands in the Gulf of Mexico. On one of the sandy coral cays arises the immense brick erection of Fort Jefferson, now derelict (figure 3). This is surrounded by a moat which was originally in free communication with the sea and in which became established a representative sample of corals and other marine organisms. In 1919, hurricane seas breached the moat, sand and debris were carried in, and free circulation ceased: it became a sediment trap. In 1934 the fauna of the moat was very different from that when the sea had free access. Only those organisms which could withstand silty conditions survived, and these included only one out of originally seven species of corals, namely *Siderastrea radians.* But the most noteworthy fact was that many of these colonies had become more rounded and had changed in skeletal form; in this way they had become capable of living in water where there was a continuous fall of sediment.

One of the greatest feats of marine engineering was the cutting of the Suez Canal. In 1924, fifty-five years after the canal was opened, the fauna was studied by a Cambridge University expedition under Professor H. Munro Fox. The greatest barrier to the migration of animals through the canal is the high salinity of the Bitter Lakes originally a dry valley but with salty deposits resulting from the drying up of a former northward extension of the waters of the Gulf of Suez. To a less extent the narrowness of the canal proper, and the stirring up of water in it by the passage of boats, affect large and small animals respectively. But despite these factors and the high temperature of the shallow water, there is now a representative marine fauna in the waters of the canal and its lakes. The animals are predominantly Red Sea species, because powerful currents flow from the Red Sea into the Bitter Lakes, while there is a slow current from there into the Mediterranean for ten months of the year. Only in fish are Mediterranean species well represented because these move independently of currents. The invertebrate animals are distributed mainly during the drifting planktonic stage of the life-history and so are at the mercy of prevailing currents. Gradually, representatives of the Indian Ocean fauna are passing through into the Mediterranean, where two of them, a pearl oyster and a swimming crab, are now firmly established.

The Dutch, in the latest and greatest of their battles with the sea, completed a great dyke across the mouth of the Zuider Zee in June 1932. By so doing they converted a wide area of saline water into a great inland lake. Before the dyke was finished a thorough survey of the animals and plants within the Zuider Zee was made, and subsequent changes in both the environment and the population were closely followed. Originally the latter consisted of a somewhat restricted though essentially marine community, but included a number of endemic species of both plants and animals. Decrease in salinity was accompanied by rise in nutrient salts and so in basic fertility, and there was a widespread change in the fauna and flora. Purely marine species, such as herring, anchovies, plaice, mussels, cockles, and crabs, and also a seal colony on the island of Urk, all disappeared. Porpoises were asphyxiated under the ice which formed on the now fresh water. Brackish-water or estuarine species, notably the solitary endemic crab, maintained themselves to some extent, but fresh-water forms which migrated down from the rivers became dominant within two years after the completion of the dyke. These included bass and carp among fish, many fresh-water plants, and also invertebrates such as the harlequin fly, *Chironomus,* which breeds in water. This became so numerous in the initial absence of enemies, that the hordes of flies arising from the water blocked the radiators of cars driving over the dyke.

After the repair of damage suffered during the war, the eventual outcome of this major change brought about by the activities of man will be the conversion of a shallow arm of the sea into a restricted and reed-bordered lake. This will be rich in fresh-water life but will probably contain a few curious remains as sole evidence of its original saline character.

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FARM FORESTRY IN THE PUNJAB.*

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To popularise tree growth among Punjabi villagers it seems that the theoretic value of shelter-belts to stop sand shifting, and the long term advantages of plantations which will eventually produce fuel and so save cowdung for the fields, are not likely to gain any rapid recognition. On the other hand the fact that closures bring hard cash makes a direct appeal as is proved by the figures of 120,000 acres of selection 38 closures applied for voluntarily in the civil districts in which the soil conservation circle is active.

Most of these section 38 closures are in sand-ruined land, not in the southern desert fringe but below the foothills, on the uplands and on the alluvial plains where the torrents of the outer hills dump their load of sand. These sandy beds form foci for dust-storms and shifting sand-dunes which move outwards from the often mile-wide torrent bed and smother fields and villages. A typical example is the Markanda torrent east of Ambala City; the sand dunes from this source are already interfering in the economy of villages two miles away from the torrent bed. Another good example is the Bhimber which flows from the Pir Panjal range in Jammu territory of Kashmir and has ruined many thousands of acres in the north and west of Gujrat district; along the Bhimber banks we have already recovered and brought under sissoo over 4,000 acres of sand. Another typical one is the Sil which rises in the Rawalpindi uplands and by the time it passes Pindighat is over half a mile in width and brings its own annual harvest of trouble, loss and death.

It is because the soil conservation circle is offering a "silk purse for a sow's ear" in reclaiming these waste places that the movement is becoming popular. The technique is comparatively simple but it needs organisation, not only of the village as a community, but of each village along the whole course of the torrent from top to bottom, else there is constant danger of losing land already reclaimed. It is for this reason beyond the scope of the individual and essentially a matter of land planning by catchments. We have made a start with our catchment plans in all the soil conservation districts but are never likely to achieve complete success until we can get these plans backed by a Land Utilization or Land Development Board with powers to coerce unwilling participants and to co-opt as members of our soil conservation team a quota of land revenue specialists, agricultural engineers and surveyors as well as our essential but sadly over-worked nucleus of forest officers.

The technique is as follows:—Starting where the torrent has left wide bays of sand, a series of live hedges of brushwood and stakes are buried in trenches set at an angle of 25—30 degrees with the current. The material used is any species which will root readily in damp sand. We are fortunate in possessing several which take root from branches, *viz.*, the *banha* bush (*Vitex negundo*), the *nara* reed (*Arundo donex*), some local willows, *Lannea grandis, Ipomea.* several figs and to a less extent *Dalbergia sissoo.* These, preferably in a mixture, are heeled into the trench with long lengths of twig buried at the middle but sticking up to from a fine-tooth comb to delay the silt-laden flood and persuade it to dump some of its load of grit.

At crucial points where torrent action is strong this type of live hedge network has to be supplemented with a little armourplating in the shape of regular spurs of driven posts between which is strapped a wall of our brushwood anchored down by boulders, and in extreme cases with wire-bound bolsters filled with rocks.

The next stage is shared by nature and ourselves. Nature provides a mat of creeping *kahi* (*Saccharum spontaneui*) on all such sand as soon as it is protected from grazing. We supplement this by transplanting clumps of *kana* (the tall cane grass *Sacharum munja*), and in the lee of each clump we plant *sissoo* stumps. Where

* Paper read at the 7th All-India Silvicultural Conference (1946), Dehra Dun, on item 5—Farm Forestry.

the sand contains good silt the *sissoo* starts height growth at once and in a matter of 4 years will have caught up and suppressed the *kana*, but where the bed is pure sand and the water table level drops to more than 6-8 feet in the dry periods the *sissoo* hangs fire and may die back year after year and may eventually have to be replaced by *khair* (*Acacia catechu*,) *mesquite* (*Prosopis juliflora*), *phulai* (*Acacia modesta*) or *kikar* (*Acacia arabica*) in the more intractable patches. Taking it generally however *sissoo* is king here and will give a harvest of fuel in 6-8 years from thinnings and of small saw logs and crooked poles in 20 years and of really good saw logs in 30. The *kahi* and *kana* grasses and later other fodder grasses and in some cases *bhabhar* grass for paper making all give interim cash returns.

Most of these reclamations are being done in land owned by a village community organised into a society by the co-operative department under our guidance, but in the western districts where the co-operative movement is generally more backward we have to depend more upon the goodwill of individual land-owners, many of whose holdings in Jhelum, Attock and Gujrat are big enough to justify direct action in offering to individuals whatever assistance our department can give them. The result is much the same in any case, except that when dealing with an individual landlord we have more scope for insisting upon a fair deal on the question of tenants' rights than when a whole community is taking sides in a landlord *versus* tenant dispute. We have often been brought in at the request of the owners as a body merely to put a screw upon tenants, grazing customs. The general tendency is for the tenants as a body to fight their landlords on every conceivable issue and defy authority wherever they can do so with impunity, so the landlords on their side seize upon these co-operative reclamation societies as a means of retaliation by obtaining government support to the restriction of grazing which of course hits the tenant harder than it does the landlord. In the case of co-operative banks, membership does not admit of such a social cleavage for it is in theory open to all, but in the nature of things we as a department can only operate village closures on the application of the owners, who are not necessarily the users. In the case of individual owners I find a tendency to be reasonable over grazing disputes, even in the case of absentee landlords who are prepared to leave to us the details of closure boundaries of concessions for users, but in the case of societies made up of a number of petty owners there is often a regrettable tendency to exploit the reclamation society as a means of "getting their own back" on their unruly tenants. In some cases the danger of being embroiled in this type of class warfare has not been appreciated by the officer who has drawn up the details of the closure, notification in the first instance and these have had to be altered when harassing restrictions on movement and access to scattered tenants' dwellings have been brought to light. We are also trying to defeat this challenge of class warfare by getting the societies to co-opt tenants or selected representatives on to the society committee.

In spite of such occasional difficulties we have now proved conclusively, in Hoshiarpur at any rate, that farm forestry pays. The figures of society income for 1945 are indeed striking. After meeting their own requirements for grass and fuel in this district, where shortage of both these things was becoming more severely felt until proper conservation was introduced, considerable cash profits went into the village owners' own pockets in 1944-45. The highest total is shown by *bhabbar* grass of which 160,000 maunds reached the Jagadhri Paper Mill and earned Rs. 6,60,000/-. Next comes the fodder grasses, which with firewood and charcoal together realised Rs. 1,92,000/-. Another very paying item is the resin collected from the *chil* pine which is distilled to make turpentine; this realised Rs. 1,67,500/-. Fines for trespass and illicit grazing of animals in closed areas which are also paid to the owners, realised nearly Rs. 9,000/-. The total cash income of 7¼ lakhs is shared of course amongst several hundreds of village co-operative societies which represent the bulk of the owners. The potential value of many thousands of acres of young *sissoo* plantations represents a very fine investment, and many fruit gardens are also being planted in the shelter of the reclaimed forest.

Having demonstrated in our established soil conservation districts that farm forestry in this form of reclamation society gives good dividends wherever tree or grass growth is fairly rapid, we have yet to tackle the desert fringe of the southern districts where sand movement is so serious and rainfall is so poor that spectacular cash returns from afforestation cannot be expected. The silviculturists four arid afforestation plots and the very infrequent use of *kana* grass as a wind-break by the villagers themselves have given us an indication of the technique required, namely a fairly elaborate network of accurately contoured windrows planted up with *kana*, *mesquite* and *kikar*. Emphasis must be put on the need for contouring on the flat desert for in arid conditions WATER CONSERVATION is much more crucial than SOIL CONSERVATION and is in fact the only basis on which the latter can be effected. We have however no district organisation yet built up in any of the

desert fringe districts (with the exception of one fuel circle range charge which covers the whole of Hissar and Rohtak districts) so that we are not yet in a position to attempt even the beginnings of our own departmental post-war five year plan. In so far as that part of Project III for the southern districts occupies a prominent place with an expenditure of Rs. 21 lakhs in the five years of this plan, we ought to be pressing on with much more extensive demonstrations and experiments which will give us the local cue on the following points :—

Size and spacing of contour *bunds* in flat sandy desert.

Stocking of contour *bunds* with trees and the best mixture and spacing to anchor the sand, using the silviculturists findings as a basis.

Maintenance of shelter belts against farm animals.

Thorough trials of the Hissar technique for growing other fodder grasses where *anjan* will not persist.

Use of *kana* grass as a source of humus in fields (*vide* "Desert Fringe Afforestation", Indian Forester, January 1946).

Grazing incidence on improved and unimproved grassland.

Rotational closures for *kahi* grass in partially reclaimed torrent beds.

How far consolidation of holdings can be made use of in sparcely populated areas to secure better husbandry on a basis of strict contouring.

Alternative community organisations where the co-operative department have so far been unable to produce a co-operative society for land reclamation.

Dr. Griffith, Central Silviculturist has summarised the essential points learnt from the Punjab silviculturist's four plots as follows :—

(*a*) complete closure is essential;

(*b*) contour soil working before sowing in lines and above 6 in. x 6 in.,

(*c*) sow plenty seed, sow early and sow it in lines, not broadcast,

(*d*) work the soil between the lines after each shower but don't disturb the plants.

Never let soil surface cake.

(*e*) keep down the weeds but do not disturb the local vegetation which appears between the lines; and

(*f*) thin out the lines as and when necessary.

PARTIAL ENUMERATION IN THE DEHRA DUN FOREST DIVISION.

BY R. SAHAI, I. F. S.

(Working Plan Officer, Dehra Dun Division.)

SUMMARY: This article describes in detail the method of partial enumerations by systematic parallel strips, 2 chains wide, followed by the working plan party, Dehra Dun forest division, during 1946-47.

2. It begins with giving a summary of indications of the Silviculturist, Forest Research Institute, Dehra Dun, about the practical application of the system. It then describes the nature of the country where the work was done.

3. On gentle slopes 20 per cent. enumerations were done in strips 2 chains wide and 10 chains apart.

4. Details are given about—

(i) fixing the direction of the strips and showing these on the map.

(ii) the instruments used.

(iii) the strength and alignment of the enumeration gangs.

(iv) closing of the enumeration books to get data for every acre, sub-compartment, or strip.

(v) the rate of progress and the cost of enumeration.

5. Suggestions are made about—

(i) using the enumeration data for plotting on the map to produce a picture of the growing stock.

(ii) using the method while the enumeration work is in progress for—

(a) stock-mapping or checking of the stock-maps.

(b) collecting other valuable information like state of regeneration, undergrowth, etc.

6. Two appendices are given. Appendix I gives detailed instructions to enumerators and to the officer in charge. Appendix II gives suggestions for the use of symbols on the map to show the result of enmerations.

7. The article concludes by recommending the use of the system for all those forests which are being worked intensively and which are on suitable terrain.

General

In a series of leaflets (*Indian Forest Leaflets* Nos. 83 to 91 and 93—Silviculture.—The Efficiency of Enumerations) the Silviculturist, Forest Research Institute, Dehra Dun, has shown that 5 to 10 per cent enumerations are probably sufficient for all practical working plan purposes and that it is not necessary to carry out 100 per cent enumerations to obtain a reasonable estimate of the growing stock provided that sampling is done in a systematic manner and at least 5 to 10 separate estimates per square mile are taken.

The working plan of the Dehra Dun Forest Division came under revision during 1946-47 and it was decided to carry out such enumerations as were necessary on this Forest Research Institute system of systematic partial enumerations.

It is interesting to mention here that systematic partial enumerations by parallel strips were carried out in the Dehra Dun Division by the working plan party under Mr. R. C. Milward, Deputy Conservator of Forests, as early as 1900. He writes as follows:—

"For the purpose of the present plan about 10 per cent of the stock in the Tirsal Working Circle (in the present Barkot Range) was enumerated by lines running east and west through the forest, 54 chains apart and 6 chains in width.

In the Thano Working Circle about 10 per cent of the stock was enumerated by parallel lines, 4 chains in width, 36 chains apart.

The stock of *sal* (*Shorea robusta*) in the improvement felling working circle was estimated more roughly by linear countings, which amounted to 5 per cent of the area. From a centre line 21 parallel lines of 2 chains width were laid out at distances of about half a mile from one another.

It will thus be seen that this system is not new, but what is new is that the Silviculturist has shown that the system is sufficiently accurate for normal working plan purposes.

Description of the Forests

The forests which were enumerated consist of the valuable *sal* forests of the division. These forests form a continuous belt stretching along the northern slopes of the Siwalik ridge, from the Jumna to the Ganges, about 48 miles long and on an average 4 miles wide. The lower parts of the Siwaliks ridge generally have easy gradients but the higher parts which run up to elevations over 3,000 ft. are often very steep, cut up and partially inaccessible. The hill forests are managed under a selection system and are separated by a 100 ft. fire line from the *sal* forests on the gentler slopes which are managed under a conversion to uniform system.

Enumerations

Partial enumerations were ordered as follows:—
For forests managed under the Selection System 10 per cent.

Uniform System—P. B. I. 25 per cent.

Other P. Bs. 20 per cent.

Fixing Direction of the Strips—The main stocking gradient is from south-west to north-east and the angle of the parallel enumeration strips worked out at 40° with the north line (magnetic declination being about 1°). The forward bearing for the compass was 40° and the back bearing was 220°. These bearings were strictly followed throughout.

Starting Point.—Work was started from Timli forest Rest House near the north-western end of the division and from this point a line, numbered zero, was drawn on the 4″=1 mile map at an angle of 40° with the north.

Width of and distance between enumeration strips—The next parallel line was drawn 10 chains away from the zero line and so on. This distance was decided because an enumerator can normally control an enumeration strip 2 chains wide and 20 per cent of the forests under the conversion to uniform in this locality were to be enumerated. On 4″=1 mile scale, 10 chains equal half an inch. Parallel lines were thus drawn on the map half an inch apart across the whole length and width of the forests along the Siwalik Ridge. These lines were numbered from 0 on either side of the zero line. Their total number came to 360. In the hill forests under the selection system only 10 per cent of the growing stock was to be enumerated. So, the lines with even numbers only were extended into the portion containing the hill forests. The selection system portion thus had lines 0, 2, 4...... 1 inch apart while the uniform system portion had lines 0, 1, 2, 3, 4, half an inch apart.

Allotment of work among Enumerators.—Each enumerator was given a map traced from the 4″=1 mile scale map showing the area which he had to enumerate. It showed the parallel lines, compartment and sub-compartment boundaries with their numbers, fire lines, motor roads, cart roads, numbers on boundary pillars, the direction of the north line, the scale, etc.

On the assumption that an enumerator could in this type of country enumerate 20 acres a day, that is a strip 2 chains wide and 100 chains long, or say 500 acres a month, each map given to an enumerator showed an area with as well-defined boundaries as possible about 4 miles long and 1 mile wide, that is about 2,500 acres of which 20 per cent had to be enumerated.

Diameter Classes.—Trees were enumerated in 4 inches diameter classes from 12 inches—16 inches and upwards. These were classified as sound and fit or unfit for sawing according to the United Provinces classification.

Instruments used by each gang.—(1) At the start of the work prismatic compasses, on tripod stands, were used but these instruments were found unsuitable for carrying about in the forests through thick undergrowth, etc. and were later replaced by pocket prismatic compasses which were found to be sufficiently accurate and stable. These compasses were obtained on loan from the Survey Stores Office, Dehra Dun. Their specifications are compass prismatic, liquid, 2¼″ diameter, type M.K. 3A, model 1946, made in Ordnance Factory, Dehra Dun, probable price Rs. 110/- each.

(2) Three ranging rods,8 ft. high.

(3) A Gunter's chain (66 ft. long) with 5 arrows.

(4) Six pieces of manilla rope—each 66 ft. long.

(5) Four coloured diameter tapes (8 ft. 3 inches long).

Strength of an Enumeration Gang.—Each gang consisted of 12 coolies besides the enumerator. The enumerator carried an enumeration book and the prismatic compass. The 12 coolies were distributed as follows:—

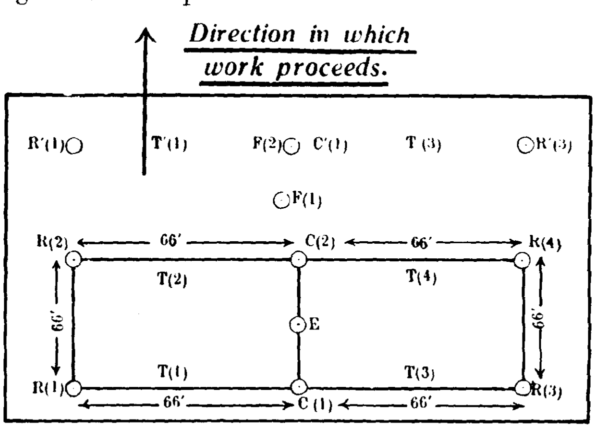
1—2 Chainsmen carrying Gunter's chain and 5 arrows.

3—4 Flagmen carrying ranging rods (in the direction of the line) and billhooks.

5—8 Linesmen carrying ropes to mark the boundary of the strip—2 on either side of the chainsmen.

9—12 Tapemen to measure diameter of trees—2 on either side of the chainsmen.

Alignment of the gang.—Given below is a diagrammatic representation of the enumeration



gang as arranged when the enumerator is about to start work. C(1) and C(2) are the 2 chainsmen. The enumerator E is at the centre of the the chain C(1)—C(2). R(1), R(2), R(3), R(4) are the 4 ropemen, each 1 chain (66ft.) away from the chain C(1)—C(2). T(1), T(2), T(3), T(4), are the 4 tapemen who measure the diameter of trees. F(1) and F(2) are the 2 flagmen in the direction of the line. F(1) is ½ a chain (or 12 steps) from C(2) and also from F(2). There is another ranging rod at E. 6 pieces of rope, each 66 ft. long, connect C(1) R(1), R(1) R(2), R(2) C(2), C(2) R(4), R(4), R(3), R(3) C(1).

When all the trees have been counted in one section 1 chain x 2 chains C(1) moves to C(2) exchanging arrows with C(2) and then, taking the end of the chain from C(2), drags it to this new position C (1) near F(2). At the same time R(1) moves to R(2), takes the end of the rope from R(2) and moves it along to his new position R (1). Similarly, R(3) goes to (4), takes the end of the rope from him and moves it along to the position R (3). As a rope remains stretched between R(2) C(2) and C(2) R(4), R(2) and R(4) are able to direct R(1) and R. (3) respectively in the correct direction (*i.e.* at right angles to R (2) C (2), C (2) R (4). In the meantime, T (1) gathers the rope between C (1) and R (1), moves to C′¹ (1), gives one end of it to C (1) in his new position C′ (1) and the other end to R (1) in his new position R. (1). Similarly, T (3) gathers the rope between C. (1) and R (3) and hands them the ends of it in their new positions, C′¹ (1) and R′. (3). The enumerator reaches C. (2) and directs F (1) and F (2) onwards in the same direction. Thus, the whole gang has advanced by 1 chain as a moving rectangle 2 chains long and 1 chain wide. As the boundaries are defined all round by stretched ropes there is no doubt as to which trees fall within the rectangle, while the chainsmen and ropemen see that no trees near them are left out by the tapeman, each of whom works in an area 1 chain x ½ chain, and there is no confusion. This is of considerable importance as with other methods there is often considerable doubt as to whether certain trees are inside or outside the strip under enumeration so that sometimes trees inside the strip are not enumerated while others outside the strip are enumerated thus giving incorrect figures. The enumerator stands at the middle of the chain to record trees and sees that the classification of trees of tapemen is correct.

In practice, it has been found that once the initial orientation of the line has been fixed with a prismatic compass negligible errors occur by following the alignment with ranging rods, while when in doubt, the prismatic compass is used to check the angle.

This system has worked satisfactorily in these Dehra Dun forests in which the country is not abnormally steep and cut up. The system is

much easier in actual practice than it appears on paper and what at first sight appears to be a complicated method of ensuring that the width of the strip being enumerated and its direction remain constant, is eminently suitable for the type of casual labour employed.

Detailed Instructions to Enumerators and Officer in Charge.—These are given as Appendix I to this article.

Closing of Enumeration Book every 5 *Chain or end of Comptt. or Sub-Comptt.*—After enumerating each acre, that is after having recorded the trees over a part of a strip 5 chains long by 2 chains wide, the enumerator draws a line across the page of his enumeration book and enters his next figures below this line. The same is done when the boundary of a compt. or sub-compt., or the end of a strip is reached. Results are thus available for each acre, compt. or sub-compt. and strip enumerated.

Work Actually Done and Rate of Progress.—Enumerations continued from 1st December, 1946 to 30th April, 1947. An area of 18,000 acres was enumerated on 900 working days, the average coming to 20 acres per day. The acreage sampled comes to 1,02,700 acres.

Cost of Enumerations.—Enumerators were paid on an average Rs. 50/- p.m. and the coolies were paid Rs. 1-5-0 per day. One ranger and 2 foresters were exclusively employed on supervising the work of enumerators. The following is the abstract of expenditure :—

Wages of enumerators and coolies.	Miscellaneous expenditure :—Purchase of ropes, chalk, etc. and repairs of tools.	Pay, T. A., record hire of establishment (ranger and foresters including the orderly, dakwalas and khallasis.)
Rs. 22,678	Rs. 236	Rs. 2,664
Grand Total.—Rs. 25,578		

Total cost of enumeration, therefore, came to Rs. 1/6/9 per acre enumerated or -/4/- per acre of the total area of the forest sampled. This includes the charges on establishment which come to -/2/4 per acre enumerated or -/-/5 per acre of the forest sampled.*

Compilation work.—As already stated under *Enumeration strips* above, the lines (and strips) cover the whole width of the division, and in order to get enumeration figures for each compartment and sub-compartment results are compiled from the enumeration books which are closed when a strip reaches the boundary of a compartment or sub-compartment. This is the most important office work of the forest ranger or other responsible officer in charge of enumerations. As each enumerator finishes an enumeration book he returns it to the said officer who compiles the results by compartments and sub-compartments and forwards them to the working plan officer.

Picture of the Forests.—As stated under *closing of Enumeration Book*, the closing of enumeration books every 5 chains gives the enumeration figures for every acre along the strip. This is the most useful and important feature of this enumeration system as the results when plotted on the 4″=1 mile scale map give a very good picture of the stocking in the forest.

The importance of this feature may be elaborated. As stated in para 9 the 4″=1 mile scale map contains on the gentler slopes parallel lines (making an angle of 40° with the north) half an inch apart. Parallel lines half an inch apart at right angles to these lines may then be drawn to give it the appearance of squared paper. The small squares will have a side of half an inch (equivalent to 10 chains) and correspond to an area of 10 acres. Considering *sal* only, trees were enumerated over 12 inches dia-

0	1	2	3		4
	E	7	4	A	1
	5	8	4	1	2
	7	8	4	8	9
	8	5	5	5	5
0	1	2	3		4

meter into 4 inches diameter classes. Let me represent trees of the 12″—16″ class (small middle-aged trees), M trees of the 16″—20″ class (big middle-aged trees) and O trees of the 20 inches

*During 1938—40 total enumerations were done in these forests on gentle slopes (which were managed under Conversion to Uniform system). The cost of enumeration, excluding establishment, came to 0-1-11 per acre, against 0-3-7 per acre of the area sampled in 1946-47, when the wages of the enumerators and the coolies were slightly more than double of those in 1938—40. The cost under the two systems are thus nearly the same.

and over class (old trees). Suffixes to these letters denote the number of trees per acre in each diameter class. O_4 M_9 m_{16} will thus mean that a particular acre has got

4 *sal* trees of 20″ and over diameter class

9 *sal* trees of 16″-20″ class

16 *sal* trees of 12 ″-16″ class.

If these letters are written against the particular square on the map to which they relate the map will give a picture of the actual growing stock of *sal* in the forest. If these letters are filled up for all squares it can be seen whether the growth in a compartment is homogeneous or not. It will also facilitate the formation of rule-compartments with homogeneous crops and the allotment of these sub-compts. to various working cricles, and periodic blocks under the uniform system. In actual practice in each small square a single letter will be filled in as explained in appendix II.

Other Uses of the System.—If trained enumerators are employed on enumeration work it should be possible to get other valubale information about every acre of the forest enumerated under this system, which the working plan officer otherwise collects only by detailed personal inspection. For example, an enumerator can record for each acre separately such information as is required regarding regeneration, the growing stock of valuable species in the classes below the diameter limit of enumeration, the presence or otherwise of species which are not enumerated, undergrowth, shrubs, climbers, grass, etc.

Such information would be very useful to the working plan officer in the sub-division of compartments and allotments to periodic blocks and he would be able to compare his own notes on any particular area with the information given by the enumerators.

Stock-Maps.—This system can also be used to stock-map the areas or to check the stock-map of those areas through which the enumeration strips pass.

Practicability of the System.—This method of partial enumeration in strips 2 chains wide, with the help of a compass and chain, does not differ much from the old system of total enumeration. In the old system the enumerator confines himself to a strip about 2 chains wide by keeping the linesmen about a chain away from him on either side. His course along the line is irregular as he has no compass to guide him in keeping in the same direction. As already mentioned the new liquid compass is very handy and convenient to enable an enumerator to keep to a particular direction. So, there should be no difficulty in following the new system except in very hilly or cut-up country.

Conclusion

The adoption of the above system of systematic partial enumerations by parallel strips is thus advocated for all forests which are under intensive systems of management and which are on suitable terrain. In steep hilly areas, specially when the country is broken and precipitous, the system is not practicable. The strips should in no case be wider than 2 chains as it is not possible for an enumerator to personally supervise the work for a distance more than one chain on either side of him. In many hill forests of the United Provinces the direction in which the strip has to go and the width of the strip cannot remain constant owing to inaccessible ground, *e.g.* on the southern slopes of the Siwaliks. In some such forests the fertility gradient changes so frequently and rapidly that the direction of the strips would have to be changed too often to cover the area in a systematic manner.

This system has thus not been adopted in certain other divisions where hill forests have recently been, or are in the process of being enumerated.

APPENDIX I

(Orders Actually Issued to Enumerators)

Rules for Partial Enumerations of Trees by Parallel Strips

1. *General.*—You have been given a tracing on cloth showing the area of the forest in which you have to work. This tracing shows the boundaries of compartments and parallel straight lines with numbers, 1 inch or ½ inch apart. It also shows the position of boundary pillars (with their number), 10 ft. compartment lines, roads, etc. These are all known points. One inch on the map is equal to 20 chains. One chain is equal to 24 normal steps of a man.

2. *Species and their Classification.*—You have to measure all *sal* and *sain* trees over 12 inches diameter, 1 chain on either side of the straight lines shown on the tracing. The trees have to be measured at breast height by coloured diameter tapes. The colours are as follows:—

12--16″	16″—20″	20″—24″	24″ and over
Red	Yellow	Black	Uncoloured.

3. Trees have to be classified as :—

Sound Fit or Unfit.

4. Unfit trees are those of which the yield is less than 1/5th of a sound tree. Fit trees are those which give more than 1/5th but less than 4/5th of the yield of a sound tree.

5. *Recording.*—When each tree is measured its name and colour (diameter) should be shouted

by the tapeman and when the enumerator shouts back its name and colour the tapeman should make a mark with chalk on the tree on the side away from the line of advance. The following marks will be made:—1 for 12″—16″, II for 16″—20″, III for 20—24,″ X for 24″ and over.

6. The enumerator will record the trees in the proper column in groups of 10 as shown below:—

1 2 3 4 5 6 7 8 9 10

7. In the hill selection working circle enumerators should work up to 20 ft. wide fire control *batta* only and not up to the Siwalik ridge which is very troublesome to reach. Further, most of those areas are unworkable.

8. In the hills they should enumerate in addition *sandan* over 8 inches *chir* and *bakli* over 16 inches diameter.

9. I want to know the number of *Ficus* trees also. So, the enumerators should count these also in future and report the number along with that *of sal and sain.*

10. *Starting Point.*—The lines on the map are all numbered. You will have to begin your work from the line which is nearest to your headquarters. All lines begin either from a fireline or outer boundary line, and generally end on the 10ft. compt. line. The lines make an angle of 40° with the north-south line. So, if you turn the compass towards 40° or 220°, you are standing in the direction of your line. You should find out from your map where your line cuts the boundary line, and find out its distance from the nearest boundary pillar. You should then chain this distance on the ground from the pillar. You should now set up your compass on this point at 220° and you are in the direction of your line. You should drive a stout peg on the ground at that point, write the number of your line on it and also on a big blaze made on a big tree nearest to it and facing the fireline. Now you are ready to start your enumerations.

11. *Composition and Alignment of Gang.*—The gang will consist of 12 men (besides the enumerator) as follows :—

1—2. Chainsmen carrying Gunter's chain and 5 arrows.

3—4. Ranging rodmen with billhooks.

5—8. Linesmen—Two on either side of the 2 chainsmen each with a rope 66 ft. long.

9—12 Tapemen—Two on either side of the chain.

12. The enumerator will set up the compass at 40° and direct the ranging rodmen in that direction. The two ranging rodmen should be about 12 paces apart from the enumerator and each other, so that the distance between them is 24 paces or 1 chain. The chainsmen will open the chain and start measuring in the direction of the ranging rodmen. The two coolies, on either side of the chainsmen, will give one end of the rope to the chainsmen, move at right angles to the chain and hold it tight to be at a distance of 1 chain from the chain. These 4 coolies will be thus at the end of a strip 2 chains long and 1 chain wide. The tapemen will then measure all *sal* and *sain* trees over 12 inches diameter in this strip and the enumerator will record them. When this has been done the chainsmen will proceed in the direction of the ranging rodmen, and the work of enumeration will proceed as before.

13. *Closing of Enumerations every* 5 *Chains or end of a Compt., Boundary or the Line.*—After recording trees every 5 chains the enumerator will draw a line across the page of his enumeration book. He should do the same when he reaches a compt. boundary, or the end of the line.

14. *Starting a New Strip.*—When the end of a line is reached a stout peg will be driven at this point, the number of the line written on it and also on a big blaze on the nearest big tree. The whole gang is then moved to the beginning of the next line. Its position is known on the map and the distance is chained. The whole process is then repeated in the opposite direction, *viz.*, fixing a peg on the beginning of the next line, writing its number on it and on a blaze on the nearest big tree, setting up the compass, realigning the gang, and starting enumeration afresh, until the boundary line is reached again and so on.

15. *Note to the Enumerators.*—He should carefully study his map and all the columns of the enumeration book and fill it in properly. The number of the strip and the compt. will be filled in before the work is begun. At the end of each day's work he should total up the trees in each column at the end of each plot, *i.e.*, every 5 chains, and ink them up. Similarly, he should ink the totals at the end of each compartment. The work must begin and end at a well-known point, *e.g.*, at the end of a line or in the middle at a 10 ft. compt. line or a road He should put in at least 7 hours field work every day.

16. Every enumerator should start work from the strip nearest to his headquarters westwards. When the work becomes distant he should start work eastwards. When work on

both sides becomes quite far he should shift camp to some other convenient place.

17. Ropes should be checked with the chain every morning.

Note to the Officer-in-Charge of the Enumeration Gang

18. After each gang of enumerators has properly learnt the work—say for 10 days—you should start checking their work. You will spend at least 3 hours daily with each gang in turn without telling them in advance about your programme. For checking you should keep a separate enumeration book and let me know the result of check with your weekly diaries in the following form:—

Name of enumerator	Dates of check.	No. of plots checked.	Total No. of trees according to (1) enumeration book, (2) checking.

19. Your diary should mention how many hours you spent with an enumerator on a particular day.

20. You should warn all enumerators that they will be discharged if the error is more than 5 per cent.

21. Enumerators should do at least 25 to 30 acres per day in the plains and 15 to 20 acres per day in the hills. The services of those will be dispensed with whose progress is poor.

22. You should check enumeration books frequently. You should check chainage with his map to see that these are correct and look to other details. This should be done daily for those on the spot and for those who are away when you check their work in the field. A detailed check should be done every off day for enumerators. To reduce your own work on that off day you can fix different days as off day for different enumerators—say Friday, Sunday, Tuesday. The enumerator should send you the enumeration book on the morning of the off day.

23. Enumeration gangs are engaged on daily labour. They cannot get any pay for the day on which they do no work (however, they are allowed one day in a week as holiday). So, if an enumerator falls ill you must appoint a substitute otherwise the gang will not be paid.

24. You should take my orders about allotment of fresh work to enumerators a week before they are about to finish their present work.

25. Enumerators should submit a weekly progress report to the working plan range officer in the following form:—

Date.	Strip No.	Chainage.	Remarks about Compt. No. etc.
1	2	3	4

26. Abstracts of these will be submitted by the working plan range officer along with his weekly diaries to the working plan officer.

27. The enumerators should be given 2 enumeration books each. You should number the pages and then give to them. You should keep 12 books in reserve with you.

28. When one book is complete, the enumerator should return it to you and start using the other enumeration book. You will check and compile the results in the following form and send it to me with the enumeration book.

Compt.	No. of strips.	Total chains.	Area enumerated.	Sal				Sain.				
Dararit (0,1,2,3) 4	T. W. (1,2) T. E.	414	83 Acres.									

29. Your papers of rough addition should also accompany your computation results so that I may not have to do the rough work of addition again. These rough papers will have the same columns as the computation result plus a column for page of the enumeration book.

30. Enumeration books are important records. These should be sent to me through some responsible man—like your orderly and *dakwalla* and must be acknowledged by me or my camp clerk.

APPENDIX II

Use of Map Symbols to show the number of sal trees of various age classes per acre

Enumeration results show that the number of *sal* trees per acre belonging to various diameter classes are as follows:—

12″—16″ class which is represented by 'm' generally vary from 0 to 20 per acre.

16″—20″ class which is represented by 'M' from 0 to 10 per acre.

20″—Over class which is represented by 'O' from 0 to 5 per acre.

2. The number per acre in each class is divided into 3 categories, I, II, III.

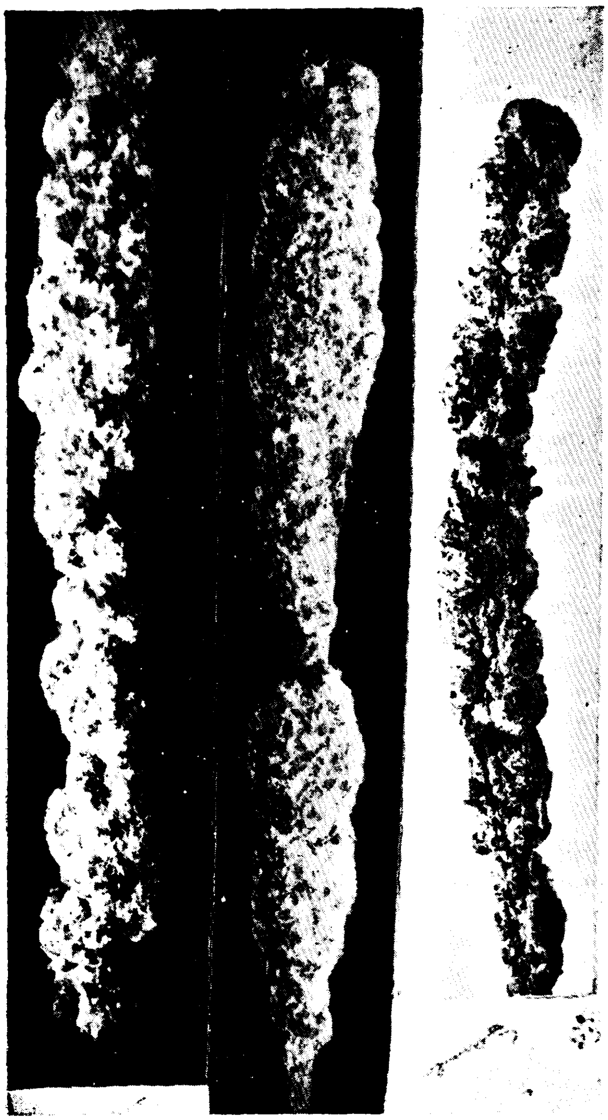
Thus O_1 will denote 20 inches and over class trees 0 to 1 per acre.

O_2	do	do	2 to 3 ,,
O_3	do	do	4 and over per acre.
M_1 will denote 16 inches—20 inches class trees			0 to 4 per acre.
M_2	do	do	5 to 8 "
M_3m will denote		do	9 and over.
m_1 will denote 12 inches—16 inches class trees			0 to 8 per acre.
m_2	do	do	9 to 16 ,,
m_3	do	do	17 and over.

3. As there are 3 classes each under O, M, m, all their permutations are $3 \times 3 \times 3 = 27$. The 9 combinations of O_1, O_2, O_3 are shown respectively as follows:—

Sl. No.	O_1 Combination.	Symbol.	O_2 Combination.	Symbol.	O_3 Combination	symbol.
I	$O_1M_1m_1$	a	$O_2M_1m_1$ ..	A	$O_3M_1m_1$	1
II	$O_1M_1m_2$	b	$O_2M_1m_2$ ..	B	$O_3M_1m_2$	2
III	$O_1M_1m_3$	c	$O_2M_1m_3$ ..	J	$O_3M_1m_3$	3
IV	$O_1M_2m_1$	d	$O_2M_2m_1$ ..	D	$O_3M_2m_1$	4
V	$O_1M_2m_2$	e	$O_2M_2m_2$ ..	E	$O_3M_2m_2$	5
VI	$O_1M_2m_3$	f	$O_2M_2m_3$ ..	F	$O_3M_2m_3$	6
VII	$O_1M_3m_1$	g	$O_2M_3m_1$ ..	G	$O_3M_3m_1$	7
VIII	$O_1M_3m_2$	h	$O_2M_3m_2$ ..	H	$O_3M_3m_2$	8
IX	$O_1M_3m_3$	i	$O_2M_3m_3$ ..	K	$O_3M_3m_3$	9

Note.—As there is a possibility of confusion between small c and capital C, and between capital I and number 1, the capital letters C and I are being replaced by J and K respectively in the table using capital letters.



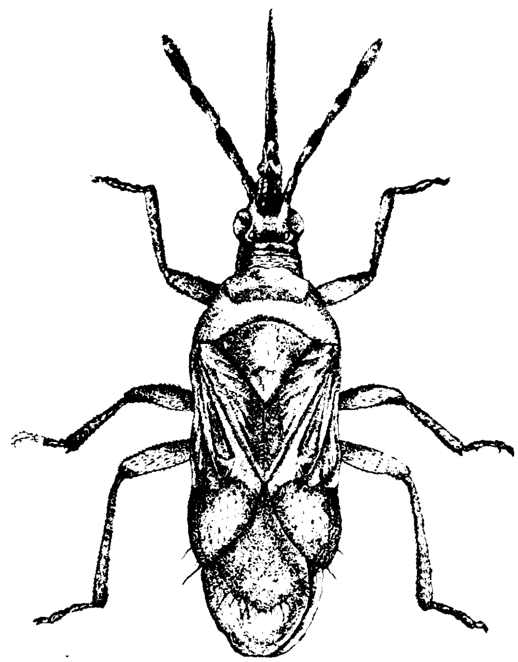


Fig. 4.

Fig. 1. Fig. 2. Fig. 3.

Fig. 1.—Fresh Mysore stick lac with previous injury due to the attack of Chrysopa larvae. Natural size.

Fig. 2.—Fresh Mysore stick lac showing an average specimen. Natural size.

Fig. 3.—Fresh Mysore stick lac showing result of injury due to Reduviid bugs. Natural size.

Fig. 4.—A Reduviid bug injurious to the lac insect; enlarged.

TWO NEGLECTED INSECT ENEMIES OF LAC

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SUMMARY: During the monsoon season *Shorea talura,* the host plant of the Mysore lac insect, suffers from the attack of aphids which invite their own enemies. Of them Chrysopa larvae and Reduviid bugs are equally injurious to lac and must be considered as major, rather than minor, enemies of lac. The kind of injury done by these enemies is shown by photographic illustrations in plate.

Critics have complained that lac cultivation is still in a very primitive condition, but nothing can be called systematic unless there is enough data collected for making a working plan for lac plantation. As far as I know there has been not even a suggestion to that effect. Before one can hope to see a working plan for lac all factors which promote and decrease its output must be listed and the share of each item quantitatively expressed. When we look into the literature no statistical method of study has been applied in lac research and even all the causes injurious to lac are not known. For example, the degree of harm done by Reduviid bugs and by Chrysopidae has never been mentioned and is being roughly calculated for the first time here.

Imms (1) and Chatterji have been the first to pronounce that "no appreciable improvement is likely to result in lac cultivation until an exhaustive and extensive series of experiments have been conducted to eliminate the insect enemies of (lac)". This suggestion implicitly states that we must know all the enemies of lac and estimate the injury quantitatively, which has not been done to this day. They were also the first to come "across two species of Chrysopa" and "one, possibly two, species of Reduviid bugs". This is all that they state with regard to these enemies.

Shorea talura.—The host plant of the Mysore lac insect, during the monsoon season, gives the best of the three crops of lac; this species is trivoltine. During the same season its leaves are liable to attack by aphids which invite their special enemies, Chrysopidae and Reduviid bugs. When a twig is horizontal, lac insects settle only on the side facing the earth. Now a Chrysopa larva crawls along the lowest level of such a twig, which means in the middle of the lac colony. It feeds upon the larvae that lie along a long narrow path leaving those lac insects that are situated on the sides. When such a lac colony is fully mature the insects on the sides have survived and by now have formed an encrustation while the dead larvae have left an empty narrow space in the centre. *Fig.* 1 *of Plate* 30 shows such a picture and contrasts with *Fig.* 2, a normal piece of stick lac.

As far as I could observe there was only one species, probably *Chrysopa khandalina.* Since the larvae, and not the adult lac insects, are attacked the degree of injury done by Chrysopa must be calculated rather than observed. The death rate of the larvae due to Chrysopa must be estimated which however becomes obvious when the encrustation is mature indicating signs of early injury such as *Fig.* 1 of *Plate* 30, clearly represents. In *Fig.* 1 not less than one-fourth of the larvae of lac have been destroyed by Chrysopa. Several of its larvae were dissected when their stomach contents were found red due to the lac dye. It thus left no doubt that Chrysopa larvae were actually feeding on lac insects. In Mysore Chrysopa ranks as a worse enemy of lac than *Holcocera pulverea.*

While adults of *Chrysopa khandalina* could be easily caught in lac plantation only a few specimens of a brown insect, probably *Micromus australis,* a Hemerobiidae, could be collected. It is probable that like Chrysopa the larvae of this insect may also prove to be enemies to lac but even then the extent of injury would be negligible.

Chrysopidae seem to be injurious even to the Chinese wax insect *Ericerus pela.* I remember reading that the Chinese cultivator of this scale insect calls one of its enemies Wax-dog. Such a term cannot but be naive but it seems to be so appropriate that it can only apply to the larvae of a Chrysopa sp. Some dogs are shaggy.

When an abnormality is found among men with the whole face covered with beard he is called a Dog-Man. The larva of Chrysopa appears, above all, a shaggy creature. Even those that feed on lac insects are covered with a mass of wax filaments which the lac insect also secretes. The Chinese, with their natural shrewdness, have found an easy method of destroying Chrysopa larvae, a procedure unfortunately unknown in Indian lac areas. The *Indian Forester* (2) reproduces an article where we read that "the farmer goes round belabouring the stumps (of branches) with a heavy wooden club during the heat of the day to rid the trees of the enemies of wax insect". I have tried this experiment which is effective as far as Chrysopa is concerned which thus confirms my interpretation of the Chinese term, Wax-Dog, as a Chrysopa larva.

The Reduviid bugs were found attacking lac in Bangalore. The specimens were sent to a specialist, Dr. Horvath at Budapest, before the war, which must now be considered as lost. One was illustrated and is being reproduced as *Fig.* 4 *of Plate* 30. The bugs were also dissected when their stomach contents left no doubt that they were feeding on lac insects. The bugs move all over and attack lac insects rather irregularly, unlike the Chrysopa larvae. The bugs feed mostly on larvae but also on very young adults. *Fig.* 3 *of Plate* 30 shows the nature of injury to lac done by bugs. A twig was observed where the bugs appeared active on a young lac colony and was marked. Subsequently when the time for harvesting lac approached this twig was collected and photographed along with an average piece of fresh stick lac *Fig* 2, *Plate* 30 for comparison. *Fig.* 2 shows the average encrustation while *Fig.* 3, lac, attacked previously by Reduviid bugs. This picture (*Fig.* 3) also indicates the contrast with the injury left by the attack of Chrysopa larvae, *Fig.* 1. When we consider the total population of these bugs in a lac area and estimate the total injury done to lac insects, the bugs would prove more harmful than the larvae of Chrysopa. In other words, injury by Chrysopa seems intensive while that by Reduviids extensive. My impression is that the total injury due to these bugs is greater than that of Chrysopa.

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A NOVEL METHOD OF CATCHING ELEPHANTS

By R. N. De., I. F. S. (Retd.)

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Readers of the *Indian Forester* may be familiar with the three usual methods of catching wild elephants **viz.**, (1) *Kheddah*, (2) *Mela shikar* and (3) Pit method. In *kheddah* or stockade, elephants are caught in herds. In the *mela shikar*, trained powerful elephants called *kunkis* are employed to place a noose round the neck of a less powerful and smaller animal which is thus caught and dragged out of the forest by sheer force. In the third method, pits are dug along the recognised elephant *dandis* or tracks and camouflaged with a covering of grass, dry leaves, etc., so that the unsuspecting animal may tumble into the pit while going along the track.

His Highness the Maharaja of Mayurbhanj has invented a new method of catching solitary wild elephants which is almost of automatic nature. The crux of this method lies in decoying the wild elephant to the place where it is intended to be caught by the noose. This needs very careful study of the habits of the solitary animal and of the forest in which the elephant roams.

The site for placing the noose is so selected that the elephant must come and place its foot inside the noose which consists of a loop of strong rope $1\frac{1}{2}$ inch in diameter with a slip knot. It tightens up round the elephant's leg and lifts it from the ground and keeps the animal fast in that position till *Kunkis* come and release it from the noose. It sounds almost unbelievable that the elephant is made to walk along the particular track and place its foot just inside the loop previously made and left on the ground, but it does work and has walked most successfully into the trap laid. To make the elephant walk along the track by which he is expected to go up to the noose, obstacles are placed on all sides except along the track. These obstacles take the form of stones or trees, etc., so that the elephant prefers to walk along the smooth ground and does not break through the track. Long before the noose is laid, stacks of paddy are placed near the site of the noose so that the elephant gets into the habit of walking up to the paddy stack for his feed. This method may appear fantastic, but when it is remembered that as many as three elephants have been caught on three different occasions, there is hardly any room for scepticism. The mechanism which catch the elephant by the leg is extremely simple

works automatically. Being accustomed to its fodder, the elephant walks along the made track by which it is accustomed to come and go to the spot where the noose is placed. As soon as it puts its foot inside the loop of the noose, the pressure of its foot releases a catch which keeps the loop in position. The noose immediately tightens round the leg and lifts it up from the ground by a mechanism which is kept concealed about a hundred yards away. The other end of the rope after passing over the branches of tree at the foot of which the trap is laid is secured to the mechanism which is fixed in the ground.

The method involves no waking at night, no driving and no danger to any human being. The success of the method chiefly depends on the ingenuity of leading the elephant on to the spot where the noose is placed by placing obstacles.

THE AFFORESTATION OF DRY AND DESERT AREAS IN THE NIZAM'S DOMINIONS

BY KHAN BAHADUR MOHAMMAD KHAN

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A. Plantation on Dry and Desert Areas

The forest areas under the control of the forest department constitute nearly 11 per cent of the total area of the dominions. These forests however are very unevenly distributed; 90 per cent of them being found in the eastern half called Telingana; and 10 per cent only in the western half called Mharathwada. The inhabitants of Telingana are, therefore, able to get their requirements of small timber and firewood easily from the neighbouring forests but in Mharathwada there is an acute shortage of both small timber and firewood. The result is that they are compelled to use cakes of cowdung, which is a very valuable field crop manure, as fuel. It is stated that dense forests once existed in Mharathwada but these were completely destroyed with the exception of a few forests now under control of the forest department. This disforestation was followed by erosion which has impoverished the soil to such an extent that large areas which were cultivated once have become fallow. Disforestation has also resulted in the sinking of the water table and the inhabitants are finding it difficult to get their requirements of water especially during the summer. It was, therefore, a matter of vital importance for the prosperity of the inhabitants that afforestation on a very large scale should be undertaken in Mharathawada. With this object in view, 7 blocks covering an area of 11,323 acres were acquired in 1945, out of which 420 acres were also sown in the said year.

Factors of locality.—The blocks acquired so far, lie on undulating and comparatively level ground. With the exception of a block in Aurangabad where the soil is black cotton overlying trap rock; the soil in the remaining blocks is sandy *murrum* resulting from the disintegration of granite and gneiss. The annual rainfall average from 18 to 20 inches, the bulk of which falls in the months of June to October, November to May being dry months.

Choice of species.—The species sown or planted were:—

(*i*) In black cotton soil—*Melia indica, Acacia arabica.*

(*ii*) On *murrum soil.—Melia indica, Acacia arabica, Albizzia lebbek, Cassia siamea, Melia azedirachta, Hardwickia binata, Eugenia jambolana,* and *Bombax malabaricum.*

Method of sowing and planting.—Sowing and planting was done on contour trenches 2 ft. wide and 1½ ft. deep dug 150 ft. apart. Ridges of made up earth were made on the downhill side of the trenches and the trenches also filled up with the soil. The seed was sown on the sloping beds formed from the top of ridge to the uphill side of the trenches. It is expensive to make trenches but this method was employed because, the average rainfall being 18 to 20 inches, it was essential to conserve enough moisture in the trenches to enable the plants to survive the dry months of November to June.

Result of sowing and planting.—Sowing and planting was done in the month of June, 1945. The seed germinated profusely and the plants have also been able to survive the dry months of November 1945 to May 1946. The height attained during the first year varies according to species and is on the average nearly 3 ft.

This success was attained only in blocks where the soil is *murrum*. But in the block where there is black cotton soil not more than 10 per cent success was attained. In this block the germination of seed was profuse as in the case

* Paper presented at the 7th All-India Silvicultural Conference (1946), Dehra Dun, on item 3—The afforestation of dry and desert areas.

of *murrum* soil but the plants mostly died after the rain when the soil dried up suddenly.

Cost per acre.—Including expenditure on nursery and establishment the cost worked out to nearly Rs. 40 per acre. The digging of trenches is the most expensive item and in spite of the fact the trenches were dug 150 ft. apart, this cost was incurred. During the current year trenches have been dug 50 ft. apart with intermediate rows of pits, this is bound to increase the cost to Rs. 60 to 70 per acre. Any suggestions by the conference to reduce the cost will be welcomed.

B. Canal Plantation

With a view to raise green manure tree plantations on banks of canals, plantation work was started on the banks of the Nizamsagar canal in 1942 and up to date nearly 60 miles length of the canal has been planted. In addition to this nearly 2 miles length of the banks of the Dindi canal were planted in 1945 with green manure tree plants.

Species.—The following species were planted:—(1) *Pongamia glabra*, (2) *Cassia siamea*, (3) *Peltophorum ferrugineum*, (4) *Erythrina indica*, (5) *Gliricidia maculata.* Mainly *Pongamia glabra* was planted.

Method of planting.—Nursery raised plants are planted in the rows parallel to the canal 12 ft. apart and in pits in the rows 12 ft. apart.

The results of planting.—The plantations have been partly successful. The two main reasons for this failure were firstly that *Pongamia glabra* which was mainly planted can thrive only on wet soils and therefore in place where deep cutting had been made and where the banks are high and dry the plants of this species failed to establish themselves; and secondly, a large number of plants planted were destroyed by cattle which cannot be prevented from grazing on canal banks under the existing law.

Necessary amendments are being made in the Canal Act to provide for exclusion of grazing from canal banks. It has also been decided that such places on canal banks which are not fit for the growth of green manure trees should be planted with fuel species such as *Acacia arabica, Melia indica, Albizzia Amara, Albizzia lebbek.* It will be evident that when such green manure and fuel plantations are established on the banks of the canals, the villages will not only be able to get green manure but these plantations will constitute an additional source of supply of fuel of which there is great scarcity at present.

CONVOCATION OF THE INDIAN FOREST COLLEGE AND THE INDIAN FOREST RANGER COLLEGE, DEHRA DUN, 1947.

The joint convocation of the Indian Forest College and the Indian Forest Ranger College, Dehra Dun, for the passing out of the 1945-47 classes took place before a very large gathering in the convocation hall of the Forest Research Institute at 11 a.m. on Monday, March 31st, 1947.

The Hon'ble Dr. Rajendra Prasad, Minister for Food and Agriculture in the Interim National Government, came to present the diplomas, certificates and prizes and to address the Convocation, and was accompanied by the Inspector-General of Forests to the Government of India, Mr. A. P. F. Hamilton, C.I.E., O.B.E., M.C., I.F.S. The chair was taken by the President, Forest Research Institute and Colleges, Mr. D. Stewart, C.I.E., O.B.E., I.F.S. With them on the dias were the Director of Forest Education, Mr. E. C. Mobbs, I.F.S., the Principal of the Indian Forest College, Mr. C.A.R. Bhadran, M.B.E., I.F.S., and the Director of the Indian Forest Ranger College, Mr. S. A. A. Anvery, I.F.S.

The presence of Dr. Rajendra Prasad attracted an unusually large number of guests, and in addition more students than ever before were present. The outgoing classes comprised 105 students, 30 from the Indian Forest College, and 75 comprising the two parallel classes of the Ranger College. There were present also a further 105 students of the 1946-48 classes, and a large number of new students just arrived for the 1947-49 courses at the two Colleges. In addition the staff of the Forest Research Institute were also present. Consequently the large convocation hall, including the gallery and balconies were packed to overflowing; probably never before has the hall seen such a large gathering. The hall is a notoriously difficult one to speak owing to its poor accoustics, so this year the Central P.W.D. were asked to arrange a microphone and amplifiers. If anyone had qualms about the effect, they were very soon put to rest; the result was excellent, and the Electrical Sub-Divisional Officer in-charge is to be congratulated on the results.

The President, Forest Research Institute and Colleges, opened the proceedings promptly at 11 a.m. with a short address of welcome to the Hon'ble Dr. Rajendra Prasad and the visitors.

Opening address by D. Stewart, Esq., C.I.E., O. B. E., I. F. S., President, Forest Research Institute and Colleges.

Dr. Rajendra Prasad, Mr. Hamilton, Ladies and Gentlemen: It gives me great pleasure to

welcome you all here to-day for this annual Convocation of the Forest Colleges. I should also like to extend a special welcome to the Honourable Dr. Rajendra Prasad, Member for Food and Agriculture in the Interim Government who has very kindly agreed to find time from his other numerous and onerous official duties to preside at this Convocation to-day and to hand out Diplomas, Certificates and Prizes to the successful students who are now completing their two-year course. We are also looking forward to hearing from him words of encouragement and advice to those who are now starting on an important career in the Indian Forests and to officers on the staff of the Colleges who are engaged on the equally important work of training others for that important career.

Forest Officers and Forest Rangers can only be trained by those who have been Forest Officers or Forest Rangers themselves. In the past it has been the custom to employ only Gazetted Officers as Instructors and Assistant Instructors at the Colleges. From this year we are introducing the innovation of having selected Forest Rangers as Assistant Instructors at the Indian Forest Ranger College. This is on the analogy of the army where warrant officers play a very important part as instructors and I do not see why the system should not work equally well in the Forest Colleges. The necessity has in any case been thrust upon us by the shortage of officers available for employment as instructors. With the annual expansion of both Colleges which is now going on to meet the ever expanding demand for trained staff from Provinces and States the annual problem of finding instructional staff is becoming increasingly difficult. Provinces and States are doing their best to help us but they themselves are in most cases very short of trained staff. The problem is bound to continue for some years until the young men turned out from our Colleges in recent years gain sufficient practical experience for some of them to come back to us for employment as instructors.

At the convocation a year ago I spoke of the expansion problems with which we had to cope both on the College side and on the Research Institute side. Since then we have been forced by the ever increasing demand from Provinces and States to expand still further. While even last year we visualised having 6 Ranger Classes in session by April 1948 (and out of these the fifth class starts to-morrow), we had not visualised having to expand the Indian Forest College beyond 2 classes doing a two or a three-year course. We have now been compelled to double this programme and a third class starts to-morrow with a fourth class being planned for next year. Last year on the recommendation of the Gwyer Committee we were contemplating extending the Indian Forest College course to 3 years instead of 2, but though this is ultimately advisable it is now clear it cannot be done until the present abnormal demand for officers has subsided.

I am sorry to say the progress with erection of College buildings and hostels has not kept pace with our necessities. The wheels of the various Government departments concerned have been revolving all too slowly for our liking. Difficulties about building material are also still present. All this has slowed up construction work and a large part of the accommodation arrangements can only be of a makeshift nature till more new buildings are ready. We have done the best we can by utilising such temporary buildings as exist, but I must warn our new students not to expect any high degree of comfort and to put up with some inconveniences for the present. This, I think, they will agree is better than having to delay the start of their training for another year.

We shall again have a good many changes in our instructional staff this year. Some of our old officers are leaving us and an increased number of new men is taking their place owing to the extra number of classes with which we now have to cope. These changes are inevitable but they increase our difficulties in running the Colleges. Such difficulties are bound to persist until we can build up a more or less permanent cadre of instructional staff. I would particularly like to thank Mr. Anvery, Director of the Indian Forest Ranger College, who will be leaving us during the next few months after 2 years of very good work in charge of this college during a particularly difficult time of expansion. I must also thank Mr. Cornwell, who is soon leaving us on final retirement and whom we shall find difficulty in replacing as the Senior Instructor in Forest Engineering. Mr. Cornelius and Mr. Saklani are also leaving us and I must thank them sincerely for the faithful service they have rendered to the Colleges.

Before closing I should like to express my own sorrow at the recent death of Sir Jogendra Singh the late member in charge of the Department of Agriculture in the Government of India. Sir Jogendra Singh was a popular and highly respected figure in our midst and who always did his utmost to further the cause of Forestry, Forest Education and Forest Research in India. I am sure you will all join me in placing on record our sorrow at his death.

I now call on Mr. Mobbs, Director of Forest Education, to talk to you about the working of the Colleges during the year.

Mr. Mobbs, Director of Forest Education, first of all associated himself and the staff and students of the Forest Colleges with the welcome

extended by Mr. Stewart to all present and especially to the Hon'ble Dr. Rajendra Prasad.

"We are very grateful to you, Sir," he said, "for finding time to honour us with your presence, despite the many pressing duties that crowd themselves upon you in these momentous days. Your presence here to-day, Sir, is an indication of the importance of Forestry in the economy of India. I sometimes feel that you should be called not simply the Hon'ble Member for Agriculture and Food, but the Hon'ble Member for Forestry, Agriculture and Food, so essential is the preservation of an adequate forest estate in India to the general welfare of its agriculture and the maintenance of its food supplies." Mr. Mobbs then proceeded to give his report as follows:—

Report of E. C. Mobbs, Esq., I. F. S., Director of Forest Education, Forest Research Institute and Colleges.

To-day we are assembled to send forth men once more from both the Forest Colleges at Dehra Dun to the Forest Services of the Provinces and many of the States over the length and breadth of India. This year they reach the record total of 105.

30 of them comprise the 1945-47 class of the Indian Forest College, which for brevity I may be permitted to refer to simply as "The Forest College". 23 of these have followed the full two years course of the College. The remaining 7 are selected Forest Rangers, deputed under the College rules for the second year of the course only. It is a great pleasure to record that these 7 Rangers have responded well to this opportunity of further training, and that all are to be awarded the Diploma of the College.

The remaining 75 men who are passing out to-day constitute the two parallel classes of the Indian Forest Ranger College, which for brevity I shall refer to simply as "The Ranger College". They have all completed the full two years course of the College.

These three classes represent the last of the war-time students, since they entered the Colleges in April 1945, when the war was still on. In those days there was not perhaps the same keen competition to enter the Forest Colleges that there is to-day. The general standard of the classes when they entered in 1945 was, therefore, I think not quite up to either the pre-war standard or to the standard we hope to attain when we reach normal peace-time conditions. Taken as whole, however, the students have done very well and great credit is due to the Heads of the Colleges and their staff for the high standard they have maintained in the training of these classes.

In both the Colleges the courses have become more or less standardized; but we are continually seeking to improve them in one way or another, so that we shall combine progress with stability. As in the past the Forest College, and to a less extent the Ranger College, has had the benefit of instruction by various officers of the Forest Research Institute in their special subjects. We are very grateful to them for their assistance. Owing to the continued expansion of the College, we are making greater demands of the Research Officers than in the past. Partially to compensate for this, the Ranger College is endeavouring as far as possible to manage without the assistance of the Research Officers, calling on them only to a very limited extent for special lectures or demonstrations.

As usual, nearly one-half of the period of training has been spent on practical field work, both at headquarters and in the forest, and on educational tours to different forest areas in various parts of India. In addition to the study of Forestry, opportunity is taken on the tours to study forest engineering works, such as wire ropeways, wet slides, forest tramways, and road, bridge and building construction, any or all of which may form an important part of a Forest Officer's or Ranger's work, and also to visit saw-mills, plywood mills and various factories connected with forest products.

The Forest College students toured extensivly to various Forest Divisions, both in the hills and the plains, in the United Provinces, Punjab, Bengal, Bombay, Madras and Coorg. I cannot over-emphasise the value of these tours, which bring the students into contact with all types of forests, a great variety of silvicultural systems, and many different methods of forest management, with experimental and statistical silvicultural research, and with the commercial side of forestry in all parts of India. On these tours they are taught the practical application of what they have learnt in the class-room; they are made to appreciate the numerous problems that confront a forest officer in the exercise of his profession, and how they are overcome; and we strive also to develop in them that faculty of critical assessment of the conditions affecting a forest, and of logical scientific decision as to the method of treatment to be applied, which is essential in every good Forest Officer.

The Ranger students do not tour so extensively; nor is this necessary. Nevertheless, it is essential that they see the main forest types that can conveniently be reached, and that they study the various works that are being carried out. They therefore tour mainly in the United Provinces and the Punjab. A final tour has hitherto been made to the teak forests of the Central Provinces. This year an innovation

was introduced in that only half the students visited the Central Provinces. The other half, comprising those from the North and North-West of India, who are more likely to be interested in dry areas than in teak, made a special tour to Sind and the dry areas of Punjab.

We should like to express our thanks to all those territorial officers whose areas were visited, to the railway and other transport administrations, and to the Rationing Authorities in Dehra Dun for their unstinting help and co-operation, without which the extensive tours of so many classes, both senior and junior, could not have been successfully undertaken.

Once again the senior classes of both Colleges attended an excellent 3 weeks' course of practical Field Engineering with the King George V's Own Bengal Sappers and Miners at Roorkee. We are very grateful to the Commandant for kindly agreeing to take 3 classes this time, and to his officers and instructional staff who conducted the course. We have been able in some measure to return the courtesy, for the senior class of the Forest College, as part of their practical work, have prepared a Working Scheme for the avenue trees and waste areas of the Roorkee Cantonment, under the guidance of the Principal, Mr. C. A. R. Bhadran. Similarly, the senior Ranger classes have recently been carrying out the field work for a Working Scheme for the cantonment areas of the 9th Gurkha Rifles, under the guidance of Mr. Arjan Singh.

All students of both Colleges are required to attend early morning Physical Training when at headquarters. We are very grateful to the Commandant of the Indian Military Academy for the services of some of his P. T. staff to conduct part of the training. The practice adopted is to have trained instructors for the junior classes, while the seniors themselves act in rotation as instructors to their classes.

Unfortunately, we were not able to arrange either a course in riding or a course in rifle firing during the past year for the senior students of the Forest College. Most of the students of the Forest College successfully completed a Course in First Aid, conducted by the St. John's Ambulance Association.

At headquarters, common messes have been maintained in the Forest College and in the two sections of the Ranger College at Dehra Dun and New Forest, under the management of student mess committees. On tour, each Ranger class has maintained a common mess, but as has always been the practice, the Forest College students have been divided into groups of six for messing purposes on tour, to give them training in making their own managements in camp.

In the Forest College the common mess is regarded as an important part of the general training of the future forest officers, and as high a standard as possible is maintained. Both Colleges, however, have suffered severe privations on account of the combined restrictions of food rationing and the amounts of the students' stipends. In the Ranger College particularly, I should very much like to see a higher standard of feeding than is at present possible. We make great demands of our students, in terms both of physical and of mental exercise, and in the number of hours we require them to work; and if we are to get the best out of them, and they are to derive the maximum benefit from the course, it is essential that we maintain both a good and a plentiful standard of feeding. Appreciating this, and in view of the present high cost of living, the rules of both the Colleges have recently been amended to provide increases in the minimum stipends of the students, the amounts now required being 50 per cent. above the pre-war rates.

The regular and active habits that characterise our courses have always resulted not only in the maintenance of a good general standard of health, but also in a very considerable improvement in the physique of our students while they are with us. The present classes are no exception to the general rule, although it is with great regret that we record the sudden death of a very popular student in the Forest College at the end of the first year of the 1945—47 course. In the Ranger College one student damaged his right hand in an accident on tour and has been unable to sit for the final examinations, while another student through sickness missed the first year examinations. Both are being awarded "aegrotat" certificates, one a Lower Standard and the other a Higher Standard.

All students are required to take part in games, and annual tournaments are held between the two Colleges and the Forest Research Institute. This year the Ranger College is to be congratulated on securing the cups for hockey, football, volley ball and athletics. The Forest College won the cricket cup.

Before calling on the Principal of the Forest College and the Director of the Ranger College to announce the results of their courses, there are one or two general matters to which I should like briefly to refer. Firstly, there is the further expansion of the Colleges, which the President has already mentioned. During the past several years both the Colleges have expanded steadily. The Ranger College has the traditions of many years to support it; but the Forest College, which dates from 1938, is still young, and since its inception it has steadily expanded. I sometimes feel that what the Forest College now

needs is a period of quiet consolidation. We should particularly like to introduce a 3 years' course in place of the present 2 years' course, which is very much overcrowded. It appears however, that for the time being this is not to be. The demand for trained Forest Officers is so great that this year we are admitting two parallel junior classes, so that there will be three classes in the College, and it is proposed to do the same next year, to bring the total to four classes. Likewise the demand for Rangers is so great that despite the reopening of the Madras Forest College at Coimbatore two years ago, we are increasing the number of classes here to five by the admission of three parallel junior classes, and next year we shall increase to six classes. When all the new students have arrived, we shall have this year nearly 300 students, 92 in the Forest College and 186 in the Ranger College.

The admission of an increased number of students must, or should, be accompanied by adequate provision for their training in the form of accommodation, equipment and staff. We have with some difficulty secured the requisite staff, although some are still to arrive, but there are serious deficiencies in respect to the accommodation and the equipment.

Among the staff, as the President has mentioned, we are losing four officers. Lt.-Col. Cornwell has helped us over a very difficult period as the senior Lecturer in Engineering and Surveying. We extend to him and Mrs. Cornwell our best wishes for a long and happy retirement. Mr. Cornelius, who is returning to the Central Provinces, served first for one year in the Forest College, and for the past year has been in charge of a class in the Ranger College. We shall miss him and Mrs. Cornelius, who has endeared herself to the students of both colleges. Mr. Saklani has been an assistant instructor in the Ranger College at Dehra Dun for the past two years. Mr. Anvery, who is due to leave us soon, has been Director of the Ranger College for the past two years, and has guided it through a very difficult period of expansion, with an almost entirely new staff. The Colleges owe to all these officers, and particularly to Mr. Anvery, a great debt of gratitude for their work during the past two years.

To replace these officers, and to provide for the extra classes, we welcome to the Forest College Rai Sahib V. P. Mathur from the Central Provinces, and to the Ranger College Sardar Bahadur Gurdial Singh Lamba, also from the Central Provinces, and Mr. Sher Singh Sahni of the Kashmir Forest Service. We also welcome three Ranger Assistant Instructors to the Ranger College: Mr. Nathi Singh of the United Provinces, Mr. Mukerjee from Assam, and Mr. Raghu Nath Kushoo from Kashmir. We hope to obtain a fourth Ranger Assistant Instructor from Bengal. We have yet to find a suitable Engineer to replace Mr. Cornwell in the Forest College, and we require a further Lecturer and Assistant Lecturer in Engineering and Surveying for the Ranger College. We are also badly in need of full time Physical Training Instructors for both Colleges, to take over control of P. T., athletics and games.

Although apart from the Engineering and P. T. staff we have obtained all the officers we require for the present, there are certain disquietening features. Firstly, there is the difficulty we have experienced in securing suitable men. Despite the attractions of life at Dehra Dun and the additional pay attached to the educational posts, it is very clear that our terms are not sufficiently attractive to draw the men we require, while Provinces are also often reluctant to let us have their best men. Coming to Dehra Dun very often involves considerable difficulties for an officer and his family, especially if there are children to be educated who are not acquainted with the languages used in the schools and colleges in this part of India. It is essential, therefore, that the conditions of service here should be sufficiently attractive to counter these difficulties and to draw the best men from the Provinces and States. I cannot too strongly emphasise that we cannot turn out first class officers and rangers from the Colleges unless we have really first class instructors. So attractive should our service be that there should be competition among the best Forest Officers all over India to join the college staffs, and Provinces and States should be prepared to cast their bread upon the waters, and to let their very best men come here. Further, service as a Lecturer or Instructor here should be regarded as a definite additional qualification should a man subsequently return to his Province or State. Only if these conditions obtain shall we be able to select the type of men we require: men of vigour and imagination, first class technical forest officers, with an aptitude for teaching, good disciplinarians, and with that personality which will enable us to turn out the type of Officer and Forest Ranger that will maintain and enhance not only the reputation of the Forest Services to which they will belong, but more important, the well-being of India's forest estate and the country as a whole.

Among our staff we have a number of officers who are within a year or two of superannuation. While age brings with it the benefit of experience, it is not, I feel, to the best advantage of the Colleges to recruit as instructors men who are soon to retire. A man who has spent all his service in one Province or State is necessarily out of touch with many aspects of Forestry

which he will be required to teach in an All-India Institution such as ours. It takes at least a year, and usually two years, before a new instructor can get himself fully up-to-date to the high standard we desire. We should like to secure as instructors men of between 10 and 20 years service, who would be prepared to stay with us for a number of years, and possibly permanently. Unfortunately, owing to the hiatus in recruitment to the Forest Services 10 to 20 years ago, such men are practically unobtainable. We have, therefore, to rely for the time being partly on older men, but we must look in the future more and more to men whom we ourselves have trained. As the first class of the Forest College passed out in 1940, we now have past students of up to 7 years service to look to. We already have two such men in Messrs. Habib Khan and Sharma, and I hope not only to recruit more in the future, but that from the best of them we shall be able in due course to build up a permanent educational cadre. One thing I should like to ensure is that each of these young men should have the opportunity of going to Oxford for the special Indian Officers' Course, which Professor Champion is now conducting there especially for past students of the Indian Forest College who have had some years service, and also that they should be able to combine some research with the course to secure the Oxford Post-graduate Forestry Diploma. I hope that before long I shall have sufficient staff to enable at least one of the younger members to be deputed to Oxford for this purpose annually.

Then there is the question of accommodation to which the President has already referred. Last year we suffered some inconvenience in that we had to start using the new Ranger College at New Forest before it was properly completed, and it was three months after the arrival of the students before the hostels for the 4th Ranger class were ready for occupation. We have to face more serious difficulties now. The new Ranger College is being expanded for the 5th and 6th classes, and one wing should have been ready to-day for the 5th class, which has already arrived. It will, I am afraid, be some months before this wing is ready, and in the meantime we shall be very congested in the existing accommodation.

Permanent hostels, with a mess, have been designed to accommodate 120 Ranger students at New Forest, and sufficient of the building should have been ready now to accommodate the 5th class. Construction has not yet even started, and I am afraid that of the three junior Ranger classes now being admitted for the 1947—49 course, the two classes at New Forest will have to share accommodation intended for one class for at least the first year of their course.

For the third class of the Forest College, we have been able to renovate the temporary war-time quarters and mess of the hospital nurses, which we hope will stand till the permanent hostels and mess are constructed. These are still under design, but we hope that construction will at least commence this year.

A permanent building for the Forest College has been designed to accommodate three classes, so that we may move out of the Forest Research Institute building, where, like the camel in the Arab's tent, we have continually spread ourselves to the detriment of the rightful occupants. But again construction has not yet commenced. We have therefore been forced to spread still more in the Research Institute building. Even so, the accommodation of the Forest College will now be in some ways definitely unsatisfactory. It is hoped that the building of the permanent Indian Forest College will be taken up as soon as possible; I would urgently request that it be completed before another year, or we may find it impossible to admit the 4th class contemplated.

There is further difficulty in the housing of the staff. Again we have been steadily appropriating accommodation intended for the research staff, and now there is nothing more available. I shall regretfully have to ask the new Ranger Assistant Instructors to occupy temporary accommodation in the hospital nurses' quarters, where they will be without many facilities.

These, Sir, are real difficulties, and in the interests of efficiency, I hope that the Government of India will see that the building programme suffers no more setbacks, but is speeded up as rapidly as possible.

The securing of the additional equipment required has also proved difficult. The teaching of scientific subjects requires scientific equipment; we require surveying and engineering instruments, microscopes and biological apparatus, and many other things. I should like to have an epidiascope in each lecture room, so useful is this instrument in the teaching of all branches of Forestry and Science. But supplies are difficult to obtain, as manufacture in India and imports from abroad are still restricted. We are securing what we can, and shall continue to get things as and when opportunity permits.

Lastly, I may mention the students themselves. The qualifications we demand are high. We have, however, made certain concessions in both colleges for ex-service candidates, regarding both age and educational qualifications. This we do willingly, although it will undoubtedly make instruction all the more difficult for us. In the interests of the forests and the country as a whole we cannot afford to lower the standard of our training to any appreciable degree.

There is, however, in some quarters a general effort to get us to lower our standards. We are all too frequently asked to relax one qualification or another "as a special case". Unfortunately, there are too many of these "special cases" for them to be regarded as "special". I would not suffer myself to be operated on by a man who had been admitted to a medical college without proper qualifications, who had not been able to follow the course, and who had consequently failed to qualify himself properly as a doctor. Neither do I consider that we should suffer our forests to be operated on by similarly unqualified forest officers. The Gwyer Committee, which considered in detail the qualifications for the Forest Colleges, was, I believe, emphatically of the opinion that we should in no way lower our standards; and as India settles down to peace-time conditions, I have no doubt that we shall have ample candidates with the qualifications we demand. In the meantime, despite the concessions allowed to ex-service candidates, and also the "special cases", we shall do our our best to maintain the high standard, the welfare of the forests demands.

In conclusion, while saying farewell and God-speed to the outgoing students, and wishing them all success and happiness in the truly wonderful career they are now entering upon, may I welcome the new students, most of whom are with us to-day. As you have heard, you will be asked to put up with certain inconveniences, and you will be required to maintain a high standard of discipline. Those of you who are ex-service men are no doubt accustomed to both discomfort and discipline, and I trust that all of you will co-operate cheerfully, fully resolved to get the maximum benefit and happiness out of your stay here with us. If you have been granted concessions in one form or another, yours will be all the more difficult a task. We may relax the entrance qualifications in your favour, but the Diplomas and Certificates of the Forest Colleges can only be awarded to those who attain the requisite technical standard to justify our sending them out as qualified officers or rangers. We rely upon you, therefore, to apply to your work here that zeal, courage and devotion to duty, that will not only ensure your successfully completing the course, but which will ensure that when you leave here the welfare of India's forests will be as safe in your hands in time of peace as were its frontiers in time of war.

Mr. Mobbs then called on Mr. C. A. R. Bhadran, Principal, Indian Forest College, to announce the results of the 1945-47 course, and requested the Hon'ble Dr. Rajendra Prasad to distribute the diplomas and prizes. Mr. Bhadran announced that all the 30 students of the class had successfully completed the course, and were to be awarded the Diploma of the College, but none had qualified for the Honours Diploma. The top student was S. A. Rahmatullah of Madras, who had gained the Hill Memorial Prize for Silviculture and the College Prize for Forest Management, and was being recommended for the award of the Currie Scholarship for the year. A list of students in their order of merit in passing out and of the prize-winners is given at the end of the report (*vide* pp. 458-459).

After the distribution of the diplomas and prizes of the Indian Forest College, Mr. Mobbs then called on Mr. S. A. A. Anvery, Director, Indian Forest Ranger College, to announce the results of the Ranger course for 1945-47, and again requested the Hon'ble Dr. Rajendra Prasad to distribute the certificates and prizes. Mr. Anvery announced that of the 75 students forming the 2 classes of the course, 4 were to be awarded the Honours Certificates, 67 the Higher Standard Certificates and 4 the Lower Standard Certificates. The top student was R. Chakravarty of Raigarh State; he was also being awarded the Honours Gold Medal, the Silver Medal for Forestry, the Silver Medal for Botany and the Silver Medal for Forest Engineering. A list of students in their order of merit in passing out and of the prize-winners is given at the end of this report.

To conclude the distribution of the diplomas, certificates and prizes, the President, Mr. Stewart, asked the Hon'ble Dr. Rajendra Prasad to present a certificate to Mr. A. C. Dey, Lower Assistant, Chemistry and Minor Forest Products Branch, Forest Research Institute, in token of his having been awarded the Howard Medal for Research for the year 1946 for his research work on Ocimum. This medal is presented annually under a trust fund founded in 1945 to that member of the subordinate technical staff of the Forest Research Institute, whose work is judged by the President to be the most important contribution to the advancement of reasearch at the Institute during the year.

The President then asked the Hon'ble Dr. Rajendra Prasad to address the Convocation.

Address of the Hon'ble Dr. Rajendra Prasad, Minister for Agriculture and Food, Interim National Government.

Mr. President, Ladies and Gentlemen.—It is a matter of great pleasure to me to be present on this occasion and to distribute prizes, diplomas and certificates to those who have passed out of the Indian Forest College and the Indian Forest Ranger College after receiving their scientific and practical training. I wish to offer to them

my congratulations and good wishes for a successful and useful career of service on which they are going to enter.

Forests are assets of great value to any country. Directly they give timber, fuel wood and charcoal, which are all necessary and play an important part in the life of any community. Timber is an important industrial raw material which is required for building and furniture and is thus seen in every-day use in every house from a cottage to a palace. It has other numerous uses beginning with the handle of a simple small primitive agricultural implement used by a villager right up to parts of an aeroplane and highly scientific and accurate instruments. Wood and other forest products are used in numerous other industries, such as paper-making, and nowadays I am told wood powder can be used for adulteration of wheat flour. Other forest products give us a number of edible fruits, nuts and roots and tubers, any number of medicinal plants and flowers, fruits and roots and barks which can be and are used in innumerable ways. I may mention for example various kinds of dyes of the most exquisite hue. In short, it is impossible for me to enumerate the direct uses to which forest products are put. They furnish grass and fodder to cattle and are the abode of the fauna and flora of a country. The indirect value of forests is equally great. They affect the climate and particularly the rainfall and thus help agriculture. They furnish natural manure, which is carried by streams during and after the rainy season to cultivated land, and they prevent soil erosion and flood. If they are well managed the benefit derived from them can be immense; if not managed or mismanaged they can do immense damage and can at best remain a nuisance to the community. It is, therefore, the duty of the State to manage them well so that they can be used to the best advantage. You who have received prizes, diplomas and certificates are going out to join that band of workers in the field who have been engaged in this most useful attempt to manage well our forests.

India has immense forests spread all over the country and it is an immense and tremendous enterprise to manage them well. While the work is great, the difficulties are equally great, and what is needed is not only scientific and practical training but also heart and enthusiasm in it. I am sure I am casting no reflection on the work that has so far been done when I say that much—very much—remains to be done. Take some of the items I have mentioned. Do we get as much timber and of the quality that we should and could get out of over a hundred thousand square miles that are covered by Government forests in this country? They constitute nearly one-fifth of the total area of our soil. The total yield of timber from these forests in so far as figures are available does not exceed 1½ million tons a year. The annual yield of charcoal and fuel does not exceed 4½ million tons and the total value of our forest products for Birtish India is 3 crores of rupees. In other countries which are somewhat better developed the yield per square mile is much greater. I have given you the total value of forest yield. The amount spent on the forests and the department which looks after them is 2¼ crores per year thus giving us as net revenue the paltry sum of Rs. 75 lakhs per year. I have no doubt that all this can be increased tremendously, almost to an unlimited extent.

Forest development undoubtedly takes time to show results. It is not like a crop of grain which can be produced within a few months—some of the crops can be raised within a few weeks. A forest takes years, but that is no reason why we should not lay our plans on an extensive scale and work for results which may not be all available within our lifetime.

As regards flowers, fruits and roots that are available in abundance in our forests, there is a vast field which remains unexplored. I wonder if there is anything in nature which has not some use or other. Even what are regarded as pests and carriers of one kind of disease to animal and vegetable life may be used as preventives or cures of other kinds of malady or even for the disease which they propagate. Scientific research has opened out immense vistas which are waiting to be explored. Our forest products furnish a most fruitful field for research. The Institute is doing much and can do a great deal more to enable every little thing to be utilised and converted into a highly valuable product. Our people have known from time immemorial how to utilise some of these products, the value of which is only now being brought home to us. *Hare*, *bahera* and *amla* grow wild in our forests. Our indigenous system of medicine looks upon them as almost a panacea for all diseases. There is a common saying that even a mother may prove false to her children and be unkind to them but never *haritaki*. The value of *amla* has been already recognised. I have mentioned only the commonest of fruits which are used for medicinal purposes. It is well-known that *Hare* furnishes material for a dye and so also does *Katha*. There are many other fruits, leaves, flowers and roots—too numerous to mention—which have been used as cures. There is a common belief among our people that there are plants to be found in forests a leaf or a flower or a fruit of which can sustain human life for an incredible length of time and that *sadhus* who live in forests live on such things. While there may be exaggeration in particular stories that

one may hear, I believe there is a substratum of truth in the general proposition that there are plants which can and do sustain these *sadhus*. Is it not for modern science to find out and investigate the properties of these which grow wild and without cultivation? It would require thousands and thousands of investigators and years and decades to pick up each plant that one can see in the immense expanse of our forests which we see growing and flourishing from the snowy regions of the Himalayas to the hot and humid regions of the south, from the dry and burning deserts of Sind and Rajputana to the ever-wet and green tracts of the north-east and south-west of India.

Thoughtless and imprudent denudation of forests by indiscriminate felling of trees and uncontrolled grazing by cattle is causing incalculable injury to our forest resources. I do not know what proportion of the forests can be converted into cultivable land—it may be there is room for expansion of agriculture by converting forests to cultivation. But one thing is certain; this should be done after careful investigation and according to a plan, so that the evil effects flowing from destruction of forests may be avoided: unless that is done it will be only jumping from the frying pan into the fire. We may bring some land under cultivation by cutting down forests and at the same time by doing so we may be converting other good cultivated land into a desert. I was shown a map only two days ago which indicated how the desert area in India is expanding. The causes of this expansion have to be investigated and if destruction of forests is found to be a contributory cause, as it very probably is, then the sooner steps are taken to prevent it the better. Anyone who travels extensively in this country with his eyes open cannot fail to be struck by the immense tracts lying uncultivated on account of deep furrows which look like ravines. I am told that is due to erosion, which has resulted from the destruction, mismanagement or want of management of forests. I believe it is not beyond the resources of science to control, if not to prevent this.

I have indicated only some of the problems which strike a layman that await investigation and require a planned solution. You, who have received scientific training, owe it to the country and to the institution which has equipped you with knowledge to do your best to find solutions for them. It is not given to every man to be successful as a scientist and research worker, to discover new methods and fresh solutions for problems, but it is not only easy for every man, but it is indeed his duty to do the best he can to apply the knowledge he has to be best used. You are better off than others who receive prizes and diplomas and certificates at the end of their career at a teaching or training institution. You have an assured career, while others qualify themselves only to be able to start on their search for a career. Your field of activity is already known and set for you, while others start on an unknown journey. You have, therefore, all the greater responsibility of bringing the knowledge and training you have received to bear upon the numerous and varied kinds of work that you will find waiting for you. Go ahead with a determination to see that you will make the forests you serve the life-giving and health-giving assets that they ought to be—not only sources of large revenue in themselves that they should be but are not yet, but also the support and mainstay of many other industries—including agriculture—which they are designed and destined by nature to be. Your work will not be easy, your life will not be soft. But I assure you both will be interesting and will give you opportunities that ought to satisfy the ambitions of any man. Take them with both your hands and make the best of them.

In conclusion, the Hon'ble Dr. Rajendra Prasad in a few well-chosen words of encouragement and advice wished the passing out students all happiness and success in the careers on which they were now entering.

The Inspector-General of Forests, Mr. Hamilton, then rose to thank the Hon'ble Dr. Rajendra Prasad for coming to the Convocation. He took the opportunity not only of referring to the speeches of the President, the Director of Forest Education, and the Hon'ble Dr. Rajendra Prasad, but also of addressing a few words to new students present and to the Instructional Staff of the Colleges.

Address of A. P. F. Hamilton, Esq., C. I. E., O. B. E., M. C., I. F. S., Inspector-General of Forests.

Mr. Hamilton first referred to two points in the speeches of the President and the Director of Forest Education. Firstly, regarding the recommendation of the Gwyer Committee report that the educational staff at the Colleges should be made permanent, he said that this matter had been referred to the Provinces for opinion, and he hoped that a decision would be reached before the end of the year. Secondly, regarding the affiliation of the Colleges with an University and the consequent raising of the

Indian Forest College to a degree standard instead of a diploma, and of the Ranger course to a diploma instead of a certificate standard, he said that although the intention of the recommendation was that the degree course must be a 3-year course, it was most unlikely that it would be possible to introduce the 3-year change until expansion requirements had been dealt with; question had, however, been put to the University authorities as to whether it would be possible to institute the degree course while it still lasted for two years only.

Referring to the speech of the Hon'ble Member, the Inspector-General of Forests said that there were two important points which could be considered together. The first was that the forests of India could be made to give a higher financial return, and the second that the growing of forests was a long-term matter. The important matter which emerged from these two considerations is that forestry must have a long-term policy to ensure continuity and this policy must include continuity in finance, as well as in its other aspects. Once capital has been invested in establishing plantations, etc., it is necessary that money should continually be forthcoming for the care and maintenance of these plantations and for staff to carry out the necessary works. Forestry in the past had suffered severe setbacks as a result of changing policies; at times forest budgets had been cut to the bone, as a result of which either there was insufficient staff to protect the forests from fire or other damages, or funds could not be found to carry out the necessary cultural works. He was quite certain that if the Forest Department in India were given a fair deal, it would surely "deliver the goods".

Speaking to the new students, the Inspector-General of Forests contrasted the difference between the training at the Indian Forest College and the Forest Rangers College. The training at the former College was intended to produce officers who should be able to make plans for and manage a large forest estate; it would be their duty to direct operations and they should be masters of the science of forestry. Therefore their training had to cover as wide a field as possible; but since they had to supervise the work done by subordinate officers they themselves must also have an adequate knowledge of detail. Only by possessing their charge to respect them and do the best work for them.

At the Forest Rangers College training must be essentially of a practical nature. The Forest Ranger was the back-bone of the Forest Department inasmuch as his duty was to put into effect the plans made for the development of the forests. While the gazetted officers might be considered as the architects of the forests, the Forest Rangers were the craftsmen and it was on their skill that the building up of the forests depended. They must therefore be prepared to learn their work in the most practical ways possible and should not mind even using their own hands. They too would have to learn something of the science of forestry, for without this knowledge they would not be in a position to understand the plans which they would be expected to carry out, but they must at all times realise that they were the practical craftsmen of the forests. To both classes of students the Inspector-General of Forests recommended that they should spend as much of their spare time as possible studying trees and forestry out of doors rather than in the classes. There were, he said, excellent examples and experiments to be seen in the 500 acres of experimental plots in the Research Institute grounds.

Turning to the Instructors, the Inspector-General of Forests exhorted them to be patient and to study the individual character of each student as much as possible. The class should not be looked upon as just a class, but as a number of individuals each of whom would require special understanding and coaching. This was particularly important during the tours. And it was not only in the lecture room that the Instructors should train their students, but they should also influence them to their best ability in the matter of character and this would best be done through personal example.

Turning to the Hon'ble Member, the Inspector-General of Forests said that when the programme for the Hon'ble Member's visit was first drawn up they were all afraid that in their enthusiasm they had made it too long for one who was so busy; but the Hon'ble Member had outrun even their enthusiasm and had shown this by the great interest he had taken in both the Colleges and the Institute and particularly by asking for extra time to enable him to make a more extensive tour of the Institute and for a discussion with the research officers. The Inspector-General of Forests felt sure that the future of forestry in India would be safe in the hands of the Hon'ble Member and with this he proposed a hearty vote of thanks.

The Convocation ended with three very rousing cheers for the Hon'ble Dr. Rajendra Prasad, led by Mr. S. A. Rahmatullah, the student who passed out top from the Indian Forest College.

INDIAN FOREST COLLEGE

1945-47 Class, who passed out on March 31st, 1947

Pass Diploma.— *(In order of merit).*

1.	S. A. Rahmatullah, B.Sc.	Madras.
2.	K. K. Nair, B.Sc.	Madras.
3.	T. P. Viswanathan, B.Sc.	Travancore.
4.	D. P. Joshi, B.Sc.	United Provinces.
5.	I. M. Qureshi, B.Sc.	Bombay.
6.	B. N. De, M.Sc.	Bengal.
7.	J. K. Ganguly, M.Sc.	Bengal.
8.	A. A. Gilani, M.Sc.	Bahawalpur.
9.	B. K. Sahay, M.Sc.	Bihar.
10.	B. N. Nandi, B.Sc.	Bihar.
11.	Niranjan Singh, B.Sc.	Punjab.
12.	N. P. Tripathi, B.Sc.	United Provinces.
13.	S. S. Mandal, M.Sc.	Bengal.
14.	T. B. J. Chetty, B.Sc.	Madras.
15.	L. Rynjah, B.Sc.	Assam.
16.	S. P. Jadhav, B.Sc.	Bombay.
17.	M. M. Islam, B.Sc.	Assam.
18.	S. M. Wagle, B.Sc.	Bombay.
19.	S. Muhammad, M.Sc.	Bihar.
20.	K. K. Somaiah.	Coorg.
21.	C. S. Soundal, B.Sc.	Terhi Garhwal.
22.	S. H. Korlhalli, B.Sc.	Bombay.
23.	Deep Singh, B.Sc.	Orchha.
24.	G. K. Das, B.Sc.	Orissa.
25.	V. M. Wagle, B.Sc.	Bombay.
26.	A. M. Salaria, M.Sc.	Kashmir.
27.	C. M. Joshi, B. Sc.	Bombay.
28.	M. A. H. Chowdhury, B.Sc.	Assam.
29.	P. T. Devassy, B. A. (Hons.).	Cochin.
30.	G. M. Shankariah, B.Sc.	Mysore

Hill Memorial Prize for Silviculture	S. A. Rahmatullah, B.Sc. (Madras).
College Prize for Forest Management	S. A. Rahmatullah, B.Sc. (Madras).
College Prize for Botany	B. N. De, M.Sc. (Bengal).
College Prize for Engineering and Surveying	N. P. Tripathi, B.Sc. (U. P.)
College Prize for the best all-round student and the most practical forest officer	T. P. Viswanathan, B.Sc. (Travancore).

INDIAN FOREST RANGER COLLEGE

1945-47 Class, who passed out on March 31st, 1947

Honours.— *(In order of merit).*

1.	R. Chakravarty, B.Sc.	Raigarh.
2.	P. N. Brodoo, B. A.	Kashmir.
3.	K. G. Vasudevan, B. A.	Cochin.
4.	G. G. Udhwani, B.Sc.	Sind.
	Higher Standard —	
5.	J. Shetty.	Madras.
6.	A. P. Mohanty, B. A.	Mayurbhanj.
7.	H. S. Singh	Khairagarh.
8.	H. D. Roy.	Bengal.
9.	V. P. Velhankar.	Bombay.
10.	K. D. Sharma, B.Sc.	N.-W. F. P.
11.	Mohd Sharif, B. A.	Punjab.
12.	G. A. Siddiqi, B. A.	Punjab.
13.	H. D. Dhasamana, B. A.	United Provinces.
14.	Mohan Chowdhury, B.Sc.	Jodhpur.
15.	M. N. Pathak, B. A.	Central Provinces.
16.	J. S. Chauhan	United Provinces.
17.	R. N. Patil, B. A.	Bombay.
18.	Kartar Singh	Central Provinces.
19.	I. D. Sharma	Chamba.
20.	D. D. Sharma	Punjab.
21.	Abdur Rahim, B. A.	Kashmir.
22.	Mohd. Moosa	Madras.
23.	S. R. Khanzanchi, B. A.	Kashmir.
24.	P. L. Puwar	Bombay.
25.	M. C. Dolbarua	Assam.
26.	B. Ahmed	Assam.

INDIAN FOREST RANGER COLLEGE—(*continued*).

1945-47 Class, who passed out on March 31st, 1947 (In order of merit)

No.	Name	Province
	Higher Standerd —	
27.	W. M. Ansari	United Provinces.
28.	Yash Pal Bajaj	Punjab.
29.	S. S. Hussain, B. Sc.	Hyderabad.
30.	S. A. R. Shah	N.-W. F. P.
31.	Mohd. Irshad, B.Sc.	Mandi.
32.	H. C. S. Bist	United Provinces.
33.	S. K. Sahaya	Bihar.
34.	K. D. Sharma, B. A.	Bihar.
35.	S. S. Puri, B. A.	Kashmir.
36.	P. S. Pokhryal	Bengal.
37.	Amarjit Singh, B. A.	Punjab.
38.	P. Pradhan	Orissa.
39.	M. M. Srivastava, B. Sc.	Bihar.
40.	A. C. Dhawan	N.-W. F. P.
41.	M. S. Yadav, B. A.	Jaipur.
42.	H. K. Mahajan, B. A.	Bombay.
43.	K. L. Verma	Central Provinces.
44.	R. B. Giriyappanavar	Bombay.
45.	Hardyal Singh, B. A.	Bikaner.
46.	I. B. Sheikh	Sind.
47.	K. A. Chaudhary	Bengal.
48.	B. Gupta, B.Sc.	Bihar.
49.	Ghulam Qadir	Kashmir.
50.	G. H. Surahio	Sind.
51.	H. C. Gupta	Kotah.
52.	G. N. Raimajhi	Nepal.
53.	P. L. Argal, M. A.	Central Provinces.
54.	P. R. Reddy	Hyderabad.
55.	A. Z. M. Labib Chaudhry	Assam.
56.	M. A. Qureshi	N.-W. F. P.
57.	N. D. Chaudhari	Kashmir.
58.	A. R. Khan	Central Provinces.
59.	S. V. Pandit	Bombay.
60.	R. Malhotra	Patiala.
61.	Bhim Singh	Jubbul.
62.	J. S. Bali, B. A.	Kashmir.
63.	N. P. Tiwari	Central Provinces.
64.	R. C. Vyas	Dhar.
65.	A. M. Memon	Sind.
66.	P. M. Bhopti	Dangs.
67.	M. Hussain-ud-din	Madras.
68.	G. M. Singh	Nepal.
69.	R. Sambhamurthy	Madras.
	Unplaced.—	
	H. Bahar	Iran.
	S. Subbarao	Madras.
	Lower Standard.	Rewa.
70.	G. D. Srivastava*	
71.	Atul Singh Bist	Tehri.
	Unplaced.—	
	B. Yassamy	Iran.
	Gupteshwar Prasad, B. A.	Bihar.

Prize	Winner	Province
Honours Gold Medal.—(To the student gaining most marks in all subjects throughout the course)	R. Chakravarti, B.Sc.	Raigarh.
Silver Medal for Botany	R. Chakravarti, B.Sc.	Raigarh.
Silver Medal for Forest Engineering	R. Chakravarti, B.Sc.	Raigarh.
Silver Medal for Forestry	R. Chakravarti, B.Sc.	Raigarh.
Fernandez Gold Medal for Forest Utilisation	A. P. Mohanty, B. A.	Mayurbhanj.
McDonnel Silver Medal.—(To the best student from the Punjab or Kashmir)	P. N. Broddo, B. A.	Kashmir.
William Prothero Thomas Prize.—(To thebest practical Forester).	Mohd. Sharif, B. A.	Punjab.
Ind. For, Prize.—(To the best student who has recvd. no other prize)	K.G. Vasudevan, B.A.	Cochin.
Director's Prize.—(To the second best student who has received no other prize)	G G. Udhwani, B.Sc.	Sind.
Hazarika Memorial Medal.—(To the student gaining highest marks in tour examinations)	K. D. Sharma, B.Sc.	N.-W. F. P.
Marathan Race Cup (8 *miles*)		
1. Inspector General of Forest's Cup	H. N. Patil, B. A.	Bombay.
2. Second Prize	B. S. Belwai	Bombay.
3. Third Prize.	I. D. Sharma	Chamba.

* A lower standard certificate was graneted at the Convocation to Mr. G. D. Shrivastava, by mistake instead of the higher standard certificate to which he was entitled.

EXTRACTS

IN FOREST BY-WAYS.

By J. W.

(Random Reflections on Woodland Life)

As I picked up one of the six volumes of Schlich's "Manual of Forestry" I noticed a slip of paper within. Two or three passages were marked "References to the greater tranquillity of the human mind in forests," and to the "salutary effect of forest air," and a statement that "as forests increase the artistic beauty of a country, they must influence the character of the people, especially as they are favourite places of recreation." And on the slip of paper, in fastidious handwriting which I recognised as that of a Polish forester friend, was the comment: "Schilich was a sentimental German. Forests have always been the hiding-places of desperate criminals, robbers and murderers."

A few weeks later, when being taken round an East Anglian forest, I asked the forester why he was always so careful, even in the loneliest compartments, to lock the door when he left the van. "Borstal boys." came the reply. "There's a colony just over there." Laughingly I told him of the comment on Schlich's observations.

"Yes, and he might certainly have added Borstal boys. When they run away they nearly always go into the forest."

"And do they stay there ?"

"For about two or three days, till they're really hungry. Then they emerge."

Out of this particular forest, planted only after the first world war, yet, the source of hundreds of thousands of pitprops and fencing stakes for the second, was carved the largest. Fido aerodrome in England. It was made specially to receive aircraft returning badly damaged from the Continent. Often the aircraft were out of proper control, and various gaps in the plantations mark the crashing places of giant bombers. Once the forester had the right-hand door of his van ripped off by the wing-tip of a bomber. Another time a petrol tank dropped from an aeroplane and, exploding, killed a girl forest-worker. In the same forest the woodman, busy brashing, once found the remains of a German airman—little but bones and uniform—several months after he was known to have baled out unsuccessfully. There were, in fact, two victims, but the other has yet to be found.

Squirrel Damage

It was interesting to learn that here, and in one or two other East Anglian forests, there are no grey squirrels, but a considerable number of our indigenous red squirrels. Indeed, in some places the reds are numerous enough to be a serious pest, for they bite off the leaders of young pine trees, and bark trees in the pole stage. Most nature lovers in the South of England are so sad about the disappearance of red squirrels and so angry about the damage done by the alien greys, that they forget how destructive even the smaller, more handsome natives can be when they are really numerous.

An interesting reference to the subject occurs in a recent pamphlet, "Our Wood-lands," by Mr. C. P. Ackers. After having said that the grey squirrels ought to be exterminated, he proceeds: "The late Lord Lovat considered that his 2,000 acres of woodland would have yielded during the first world war timber worth £20,000 more than it fetched, but for the ravages of the red squirrel. His agent considers this to be too conservative an estimate."

Possible Changes in Wild Life

Of course, the reds are normally treated as vermin in the big pine forests in Scotland, where they are still numerous. Much has been written of the competition and rivalry between the two species of squirrel, but not everyone has yet grasped that, though there is much overlapping of their habitats, the two do not really belong to the same territories. The greys are primarily animals of the deciduous woods and of park-lands, the reds of the conifer forests and particularly of the pine forests.

It is conceivable that, as our young conifer forests grow up and more new forests are planted, the red squirrels may return to areas whence they have disappeared. But that is only one of several possible changes in our wild life which may be caused by afforestation, and particularly by the large conifer plantations. Ornithologists are already happy about the greatly improved status of crossbills, and now it is hoped that long-eared owls may return in greater numbers.

In some Welsh forests polecats seem to be multiplying, and there are grounds for hoping that the pinemartens, all but extinct a few years

ago, may become firmly re-established in certain forest areas. Unfortunately, the interests of the naturalist or amateur of wild life do not always coincide with those of the farmer or gamekeeper, and foresters form yet a third category. Foresters have been blamed, for example, for giving harbourage to deer and other destructive animals. There are far more wild deer scattered throughout England than most people imagine, and very mischievous they are, both in the forests and on the farmlands which they visit at night. It is a difficult question. If the forester, goaded by well-founded complaints of farmers or poultry-keepers, takes action against some of the offenders, he is immediately denounced by the nature lovers.

But any change in wild life serves only as a light whip to lay across the forester's back: a heavier rod is applied when he is thought to be ruining the English landscape with conifer plantations. In this matter the forester is indeed worthy of sympathy, for the attacks are so unjust. First, the aspect of the countryside as a whole will be little altered (though some local changes are inevitable) by the new plantations—they are too modest in size and number, and the effect on the scenery of hedgerow trees and small deciduous woodlands is relatively so much greater. Secondly, there is an increasing tendency to mix beech in the conifer plantations, in sites where it will grow, and to plant birch, popular and other broadleaved species on the edges of pure pine compartments. Thirdly, the country really needs conifer timber much more than hardwoods.

Also, beauty is proverbially in the eye of the beholder, and the conifers would be found to be quite as beautiful as ancient oaks if people could look at them without prejudice. Let us forget, for a moment, the horizontal lines of the old parkland oaks. Consider the conifers as quite different, or new forms, their main lines vertical rather than horizontal, their forms balanced and regular. The straight clean boles which the modern forester loves (for timber's sake) have a spare and classic grace of their own. The man who denounces them as ugly surely advertises the limitations of his taste. Some of the old-style forests should certainly be preserved, but the plantations of our own age should as certainly be recognised as an addition to the beauty of the countryside.

FOREST WILDLIFE MANAGEMENT LOOKS AHEAD.[1]

LLOYD W. SWIFT[2]

The interest of the Divisions of Forest Recreation and Forest-Wildlife are commonly focussed on similar uses of the forest areas. Forest-wildlife management's first concern is the production and utilization of wildlife resources for public recreation. In addition, the wildlife workers in common with the recreation workers are sensitive to the importance of maintaining all those natural and attractive conditions that give a forest area the elements that make it desirable for various forms of outdoor recreation.

Until some of the developments over the past decade in the field of wildlife management are enumerated, one is not likely to appreciate how much has transpired in this field. For this reason I should like to list a number of occurrences that have had some influence upon the national interest and progress in the field of forest recreation and forest-wildlife management.

Development of Wildlife Management

Enactment of Taylor Grazing Act in 1934.—This law placed a vast area of public domain range land under federal administration. An individual representing the wildlife interests is a member of each advisory board.

Establishment of the Soil Conservation Service in 1935. This organization recruited a group of technical biologists, and they have skilfully woven wildlife food and cover developments into the soil conservation practices.

Creation of the Co-operative Wildlife Research Units.—Beginning in 1935 and involving 10 universities, they have resulted in the training of several hundred well-qualified wildlife managers. The unit at Logan, Utah, is typical.

Marked development of the state fish and game commissions, including plenary powers.—This has greatly strengthened the state departments, and has facilitated the application of biologically sound fish and game seasons, and other regulations.

The North American Wildlife Conferences.—Started in *1936*, they have brought together large groups of administrators and technicians for a healthy interchange of ideas and experiences.

Establishment of a Division of Wildlife Management in the Washington Office of the Forest Service in 1936.—Subsequently, regional wildlife men were assigned to all national forest regions, and forest-wildlife specialists were placed on some forests.

Passage of the Pittman-Robertson Bill in 1937.—Without question, this federal legislation has been an important motivating force in the rapid swing of state game departments to a factual basis of game management. It has been responsible for the employment of many technicians and the development of a working corps of professional wildlifers. Already a few of the men who started as federal aid employees have advanced to the directorship of state game departments.

Formation of the Wildlife Society in 1937.—This combined the game technicians into a professional society, and has provided professional solidarity and the maintenance of professional standards. The *Journal of Wildlife Management*, published by the Society is a working tool for game technicians.

The combining of the Biological Survey and the Bureau of Fisheries in 1940.—This consolidated the federal wildlife agencies and increased their influence in this field. The refuge system has been enlarged, close contacts are maintained with the states through the Pittman-Robertson federal aid work and through administration of the migratory bird laws.

There has been a notable increase in opportunities for college work and degrees in wildlife management. To the Divisions of Forest Recreation and Forest-Wildlife Management it is of particular significance that most of the college and university wildlife work is in or associated with, a school or department of forestry. Consequently, most wildlife technicians are being trained in a forest school environment and most foresters are exposed to some courses in wildlife management. These relationships should go a long way in helping to bring about a better understanding of the management considerations and recreational aspects of forest-wildlife management.

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1. Talk given before joint meeting of the Divisions of Forest Recreation and Forest-Wildlife Management, annual meeting, Society of American Foresters, Salt Lake City, Utah, Sept. 11, 1946.

2. Chief Division of Wildlife Management, U. S. Forest Service, Washington, D. C. Senior member, S.A.F.

The recent creation of the Division of Forest-Wildlife Management in the Society of American Foresters is the culmination of a growing recognition of the important of the production of forest-wildlife and recreational use by the public.

These examples will give a picture of the extent of the national movement in the field of wildlife management. However, to view this movement in its proper perspective some consideration should be given to the general public interest in this matter.

Public Interest in Wildlife

It is not possible to present reliable figures illustrating the amount of public participation in those forms of outdoor recreation related to forest-wildlife. However, some general deductions can be made. For the nation as a whole the sale of state licenses during 1945 amounted to 8.3 million for fishing and 8.2 million for hunting. Assuming some duplication, this would mean that about 10 per cent of the people of the United States are directly interested in wildlife to the extent of purchasing hunting and fishing licenses. Obviously this does not include the great body of citizens who do not care to hunt or fish but "shoot" with a camera, enjoy bird walks, feeding chipmunks, or seeing bull elk in full antler. The food, fur, and other material gains from the use of American wildlife have considerable value but it is probably true that the social, aesthetic, and recreational values greatly outweigh the commercial considerations.

At the recent meeting of the International Association of Game, Fish, and Conservation Commissioners at St. Paul, it was apparent that the game officials looked upon the increased public interest in wildlife as constituting a permanent demand. They recognized that there is a need to provide a continuous supply of wildlife and that this presents problems to all those concerned with managing wildlife and land. It also follows that, as more intensive forest and wildlife management develops, there will be new and challenging opportunities for correlation.

Attitude of Foresters Towards Wildlife

It has been charged that some foresters are not sympathetic to any program to maintain or increase forest-wildlife. Specific accusations have been that they are unwilling to alter forest management practices in order to provide essential food and cover requirements for forest-wildlife species.

No doubt there are forest managers who have not shown an interest in improving the habitat for forest-wildlife but men engaged in the management of private forests for timber production probably lack encouragement. For the most part, there is not yet a means by which appropriate incentives can be provided to mak. it worth the private owners' time to produce a wildlife crop. It may be that this is the main limiting factor and that private forester can not be expected to make conscientious effort to increase forest-wildlife until this resource, like timber, can be made to produce an income consistent with the effort exercised in its production.

Moreover, private and public foresters have frequently found that to increase wildlife is to create management problems. A few illustrations will serve to show what often happens. The beaver has now become so common in some forest areas that extensive damage has been done by flooding and killing out forest growth, and by damming culverts and making access roads impassable. Perhaps deer have caused more trouble than any of the forest forms of wildlife. There are many instances where deer have been so numerous it was impossible to obtain forest regeneration either through planting or natural reproduction.

In addition to problems which the forest manager encounters because of damage done by wildlife, he is faced with the threat of forest fires which might be started by careless hunters or fishermen. For this very reason it is not uncommon for owners of forest lands to post their property against trespass to exclude fishermen, hunters, and other recreationists.

The situation is, however, somewhat different on public land. Here the public is shouldering the expenses of management and patrol required to carry out a program permitting reasonable use of the forest for camping, hiking, or hunting and fishing.

Production of Wildlife

Commonly a forest area will produce some wildlife even though no conscious effort is made to improve the habitat. The upsurge of deer in the cutover and burned forests of the East and Lake States is an example. But for the future the increasing and maintaining of the forest-wildlife crop may depend upon the application of forest-wildlife management techniques on the part of persons responsible for the forest areas. Moreover, because of the growing public demands for various forms of outdoor recreation, it seems obvious that there will be a need to apply measures, particularly on public land, which will maintain and increase the wildlife resources.

The degree of progress in the field of forest-wildlife management and forest recreation will depend in a large measure upon the working together of various groups concerned with the handling of the forest areas. There is a two-way obligation between the wildlife men and the timber men. The timber men must accept the fact that there is a public demand for forest-wildlife which requires that some recognition be made in forest management practices to favor fish and game. Conversely, there is an obligation on the part of the wildlife men to develop with the foresters practical tools of management which, for the most part, can be fitted to those practices which are normally applied in connection with good forest management. In the final analysis, the programs of the future will depend in no small measure on the degree of effective co-operation that the recreation group and the wildlife managers can maintain with the foresters to foster the wildlife resources within the forest complex.

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INDUSTRIAL SURVEY REPORT OF TEHRI GARHWAL STATE.

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1. Introduction

Situated between latitudes 30°3′ and 31°18′ and longitudes 77°42′ and 79°24′, Tehri Garhwal State has a total area of about 4,500 sq. miles. It is drained by two main streams, the Bhagirathi and the Yamuna which leave the state territory near Munikireti and Kalsi, respectively. The Bhagirathi is fed by two main tributaries, the Bhillangna and the Alaknanda which confluence with it at Tehri and Deoprayag, respectively. The Yamuna is met by the Tons near Kalsi and the Tons is met by the Pabar near Teuni. In this way, the whole country is drained by the Pabar, the Tons and the Yamuna in the north and the Bhagirathi, the Bhillangna and the Alaknanda in the south. The average annual rainfall varies from about 32 ins. at Tehri to 125 ins. at Narendranagar.

2. Area distribution

The total area of the state is about 4,500 sq. miles. It is distributed as below:—

(1) Forests including perpetual snows and alpine grassy areas	..	3,550 sq. miles.
(2) Total cultivation	..	350 ,, ,,
(3) Unmeasured land	..	600 ,, ,,
Total	..	4,500 ,, ,,

A. Forests.

3. *Forests.*—The total area within demarcated forests consisting of 3,550 sq. miles is distributed as below:—

A. *Coniferae*		..	650 sq. miles.
*Chir.** 1		..	455 ,, ,,
Deodar. 2	40.5 sq. miles		83 ,, ,,
Kail. 3	41.7 ,, ,,	..	
Leur. 4	.8 ,, ,,	..	
Fir 5 and Spruce 6		..	112 ,, ,,
Total		..	650 ,, ,,

B. *Broad leaf species*	..	980 sq. miles.
Oaks. 7	..	856 ,, ,,
Papri. 8	..	2 ,, ,,
Low Level *Kukat*	..	122 ,, ,,
Total	..	980 ,, ,,

C. *Grassy areas*	..	750 sq. miles.
Blanks and gaps	..	238 ,, ,,
Alpine grassy areas	..	512 ,, ,,
Total	..	750 ,, ,,

D. *Unworkable areas*	..	1,170 sq. miles.
Perpetual snows	..	1,016 ,, ,,
River beds	..	8 ,, ,,
Rocky, unproductive, etc., areas		146 ,, ,,
Total	..	1,170 ,, ,,
Grand Total	..	3,550 ,, ,,

From the above it will be seen that forest trees cover 1,630 sq. miles, grassy areas occupy about 750 sq. miles, and the rest, *i.e.*, 1,170 sq. miles are unworkable and unproductive.

4. Chir forests

The *chir* forests occupy 2,90,587 acres equivalent to 455 sq. miles. Their annual yield according to working plans is 17,79,500 c. ft. This yield is marked and sold as standing trees. Lop and top left after conversion of the above annual yield is about 25 per cent and amounts to 4,40,000 c. ft. or 5½ thousand tons nearly. At present this refuse wood goes waste. It can be utilised by destructive distillation to yield turpentine and rosin, besides various other products, *e.g.*, alcohol, methanol, acetic acid, acetone, etc.

*1. *Pinus longifolia,* 2 *Cedrus deodara,* 3 *Pinus excelsa,* 4 *Cupressus torulosa,* 5 *Abies Pindrow,* *A. webbiana* 6 *Picea morinda,* 7 *Quercus incana,* *Q. glauca,* *Q. dilatata,* *Q. semecarpifolia,* 8 *Buxus sempervirens.*

The enumerations of *chir* trees in the different forests are recorded in the working plans of state forests. The total number of trees that are available for tapping and their approximate yield of resin per year is given below:—

Forest divisions	*No. of tappable chir trees over 3 ft. 9 ins. girth*	*Total yield of resin in maunds*
Tons forest division ..	4,50,000	30,000
Yamuna forest division ..	4,50,000	30,000
Uttarkashi forest division ..	12,50,000	87,000
Tehri forest division	7,50,000	50,000
	29,00,000	197,000

At any time not more than one-sixth of the total area, *i.e.*, 48,431 acres can remain closed to grazing for obtaining regeneration. So, annually 2,42,156 acres are available for pasturage.

5. Deodar, kail and leur forests

Their areas are 25,933, 26,700 and 551 acres, respectively, making a total of 53,184 acres. Their annual yield is about 5,48,000 c. ft. Of this above 25 per cent is wasted in conversion. So, 1,40,000 c. ft. equivalent to 2,000 tons nearly are available for destructive distillation per annum.

Leur is in demand for pencil manufacture. It occupies as mentioned above 551 acres, of which 435 acres are in the Uttarkashi forest division and the rest in the Tons forest division. The total number of *leur* trees of exploitable size available in the Uttarkashi forest division is 2,254.

6. Silver fir and spruce

Besides supplying railway sleepers and building timber, they are very much in demand for paper manufacture and rayon manufacture. Spruce of certain particular specifications is in demand for aircraft construction.

These timbers can be floated down and are available at Munikireti or Hardwar on the Bhagirathi and at Abdullapur on the Yamuna. The quantities of timber which can be floated down in the Bhagirathi and the Yamuna are given below:—

Stations	*Forest divisions*	*Area in acres*	*Quantity in two available per annum*
Munikireti or Hardwar ..	Tehri forest division ..	8,299	15,299
	Uttarkashi forest dn. ..	13,557	
	Tons forest division ..	36,141	
Abdullapur ..	Yamuna forest division ..	13,739	34,916
	Total	71,736	50,215

The above calculation of annual yield is based on the figure obtained by Mr. Mobbs for the Uttarkashi forest division, which gives the annual yield to be 0.7 tons per acre.

It is well worth considering if the annual yield floated down the Tons and the Yamuna and collected at Abdullapur can be profitably transported by bus to Munikireti, or if the annual yield from the Yamuna can be transported, profitably, by ropeways from Gangnan on the Yamuna and thrown into the Bhagirathi at Nakuri for refloatation to Munikireti. The cost of either of these projects is worth investigation so as to make available, at Munikireti, the maximum quantity of these timbers for feeding one of the industrial plants mentioned in the foregoing paragraph.

For regeneration one quarter of the area, at any time, will remain closed to grazing. The area available for pasturage is, therefore, 53,802 acres.

7. Oak forests

These cover an area of 5,47,617 acres in the four forest divisions. With the wood volume per acre taken to be 2,000 c. ft. and rotation of 100 years, the annual yield of wood from these forests is $5{,}47{,}617 \times 2{,}000 = 100/109{,}52{,}340$ c. ft. $= 1{,}09{,}52{,}340 \times 60$ (112×20) tons $= 2{,}93{,}366$ tons or three lac tons.

At present, they supply the fuel requirement of the state people. The latter according to the census of 1941 number 4,00,189. Their annual fuel requirement at 2 seers per head

per day $= 4,00,189 \times 2 \times 365 \div (40 \times 27)$ tons or 2,70,498 tons. Of the this about 30,000 tons are supplied from low level *kukat* forests and communal forests.

So, the balance of oak wood available, per annum, is 2,93,366 tons—(2,70,498—30,000) tons=52,868 tons.

Out of this balance of oak wood about 100 tons are used for making charcoal and about 10 tons of *mauru* oak for the manufacture of walking sticks. The balance 52,758 tons are available, annually, for destructive distillation and other uses.

These oak forests are rich in associated broad leaf trees of which maple,* 9, alder 10, birch 11, and *Michelia* 12 can be used for the plywood industry; ash 13, *ruins* 14, *mola* 15, *ghignyaro* 16, *ban*-oak 17, and *mauru*-oak 18, give walking sticks; ash is valuable for the manufacture of measuring scales and *Salix* 19 and *kem* 20 for hockey sticks.

Closing at any time one-fifth of the total area to grazing to obtain regeneration, the area available for pasturage is 4,38,094 acres.

In these oak areas large blanks so far used as *kham* land (temporary cultivation) for potato cultivation are available for the plantation of fruit trees. For this purpose, extensive forest areas are also available for conversion.

8. Papri forests

Their total area is 1,512 acres, most of which 1,090 acres are in the Tehri forest division. The Uttarkashi forest division, the Yamuna forest division and the Tons forest division have 174 acres, 231 acres, and 17 acres of *papri* forests, respectively. The annual yield available is 700 trees over 2 ft. girth. This wood is valued for the manufacture of shuttles and combs.

9. Low level kukat forests

Their total area distributed in the four divisions is 77,965 acres. Of this, 17,012 acres are reserved for commercial exploitation in the Sheopuri range; 5,358 acres for fuel and charcoal requirements of Narendranagar town; 585 acres for the supply of fuel to the military at Narendranagar; 20 acres for the military at Tehri; 40 acres for fuel supply for jail at Tehri; 3,215 acres to form Narendranagar special reserve and 354 acres to form Simlasu and Bhaitogi special reserves. The rest, *i.e.*, 51,351 acres is utilised by the villagers to meet their requirements of fuel and agricultural implements, which yield annually 10,27,620 c. ft. or about 27,500 tons.

Scattered in these *kukat* forests are found the valuable *sal*† 21, *Khair* 22, *sain* 23, *haldu* 24, *sisham* 25, *tun* 26 and *bakli* 27, trees which are well known for their commercial timber.

Bamboo (*Dendrocalamus strictus*) is also found in these forests mixed with the above-mentioned valuable and *kukat* trees. It occupies a total area of 13,410 acres. Its annual output is about 5,000 mds.

Bahar (*Ischaemum angustifolium*) grows naturally in these forests, but its extent of growth is very small. It could be used for the manufacture of paper pulp if the supply was large enough.

Out of the whole area 55,314 acres are available for grazing.

10. Blanks and gaps

These occupy, an area of 1,52,410.5 acres in different zones of vegetation scattered over the whole state. These are best suited for the supply of grass to the villagers and for grazing their domestic animals. The total yield of grass from these should be about $\frac{1}{2}$ lac tons, annually.

11. Alpine grassy areas

These extend over 3,28,644 acres and provide grazing to sheep and goats from April to September. The total number of sheep and goats that can be provided grazing for six months in a year is about $3\frac{1}{4}$ lacs.

12. Pasturage for domestic animals

The position as regards pasturage is that during summer the alpine grassy areas, the fir forests and those blanks and gaps which lie in the latter are grazed by sheep and goats and the oak forests, similarly, provide grazing to buffaloes and cattle.

The areas which are available for winter grazing are the low level *kukat* forests, the

*9. Acer; 10 *Alnus nepalensis, A. nitida*; 11 *Betula utilis. B. alnoides;* 12 *Michelia Champaca;* 13 *Fraxinus micrantha;* 14 *Cotoneaster bacillaris;* 15 *Pyrus pashia;* 16 *Crataegus crenulata*; 17 *Quercus incana;* 18 *Q. dilatata;* 19 *Salix daphnoides;* 20 *Morus alba.*

†21. *Shorea robusta;* 22 *Acacia catechu;* 23 *Terminalia tomentosa;* 24 *Adina cordifolia;* 25 *Dalbergia sissoo;* 26 *Cedrela toona;* 27 *Anogeissus latifolia.*

chir forests and the blanks and gaps in both and $\frac{1}{5}$ of 600 sq. miles, or 76,800 acres of unmeasured land, after leaving $\frac{4}{5}$ for regeneration.

The total areas which are thus available for summer and winter grazing are, therefore, as below:—

Summer grazing	*Acres*	*Winter grazing*	*Acres*
1. Alpine grassy areas ..	3,28,644	1. Low level *kukat* forests ..	55,314
2. Silver fir and spruce forests ..	53,802	2. *Chir* forests ..	2,42,156
3. Blanks and gaps in fir forests ..	14,149	3. Blanks and gaps in 2 ..	64,636
4. Oak forests ..	4,38,094	4. Unmeasured land ..	76,800
5. Blanks and gap in oak forests ..	59,664		
Total ..	8,94,353	Total ..	438,906

Taking for granted that a sheep or a goat required 1 acre, a cow or bullock 2 acres, and a buffalo 4 acres for grazing, per annum, the pasturage required, annually by our existing livestock is given below:—

		Heads.	*Acres.*
(1) Bulls and bullocks	..	92,812	185,624
(2) Cows	..	91,819	183,638
(3) Male buffaloes	..	4,240	16,960
(4) Cow buffaloes	..	67,913	271,652
(5) Sheep and goats	..	210,938	210,938
Total	..	..	868,812

The winter grazing is confined to 4 months and the summer grazing to 8 months. So, the areas required for winter and for summer grazing for the above number of livestock are:—

		Acres	*Acres*
Winter grazing 1/3	..	868,812	289,604
Summer grazing 2/3	..	868,812	579,208

The excess pasturage available in the state is therefore:—

Summer grazing .. 8,94,353—579,208 = 3,15,145 Acres.

Winter grazing .. 4,38,906—289,604 = 1,49,302 Acres.

13. Medicinal Plants

In the various areas enumerated in para 3-A, B and C, a number of plants of medicinal importance grow, the total extent of these areas is 2,380 sq. miles, but the actual area occupied by them has not been so far properly investigated and determined.

The important medicinal plants growing naturally in the State are :—

(1) *Salam Misri* [28] (2) *Nirbisi* [29] (3) *Jatamasi* [30] (4) *Karwi* [31] (5) *Mitha Jahar* [32] (6) *Gugal* [33] (7) *Rewat-chini* [34] (8) *Ratanjot* [35] (9) *Kotki* [36] (10) *Atis* [37] (11) *Apamarga* [38] (12) *Chiraita* [39] (13) *Dudli* [40] (14) *Somaiya* [41] (15) Bhujpatra [42] (16) *Arand* [43] (17) *Brahmi* [44] (18) *Bhujpatra* [45] (19) *Harra* [46] (20) *Bahera* [47] (21) *Amla* [48] (22) *Amaltas* [49] (23) *Meda-singi* [50] (24) *Kakra singi* [51] (25) *Bel* [52] (26) *Rasut Shyob* [53] (27) *Khair* [54] (28) *Bhringraj* [55] (29) *Basak* [56] (30) *Kameta* [57] (31) *Dhoula* [58] (32) *Gokhru* [59] (33) *Rahdaturn* [60] (34) *Banhaldi* [61] (35) *Bankakri* [62] (36) *Musli safed* [63] (37) *Kachiur* [64] (38) *Rati* [65] (39) *Pakhanbhed* [66] (40) *Dhatura* [67] (41) *Dalchini* [68] (42) *Baja* [69] (43) *Guma* [70] (44) *Shiwala* [71] (45) *Kurasani ajawan* [72] (46) *Gidar tamaku* [73] (47) *Tej-pal* [74] (48) *Satamuli* [75] (49) *Mamari* [76] (50) *Podina* [77] (51) *Giloya* [78] (52) *Punarnaba* [79] (53) *Bhulkatai* [80].

Besides the above medicinal plants growing naturally in the State, *kuth* was introduced

*28 *Orchis mascula;* 29 *Delphinium denudatum;* 30 *Nardostachys jatamansi;* 31 *Gentiana kurooa;* 32 *Aconitum napellus;* 33 *Juniperus squamata;* 34 *Rheum emodi;* 35 *Onosma echiodes;* 36 *Picyorrhiza kurroa;* 37 *Aconitum heterophyllum;* 38 *Achyranthes aspera;* 39 *Swertia chirata;* 40 *Taraxacum officinale;* 41 *Valeriana officinalis;* 42 *Betula utilis;* 43 *Ricinus communis ;* 44 *Hydrocotyl asiatica;* 45 *Viola serpens;* 46 *Terminalia chebula;* 47 *T. belerica;* 48 *Phyllanthus emblica;* 49 *Cassia fistula;* 50 *Crypto-lepis buchanani;* 51 *Pistacia integerrima: galls :* 52 *Aegle marmelos* 53 *Berberis chitria;* 54 *Acacia catechu;* 55 *Eclipta erecta;* 56 *Adhatoda vasica;* 57 *Mallotus philippinensis;* 58 *Woodfordia fruticosa;* 59 *Echinops echinatus;* 60 *Smilax species;* 61 *Curcuma aromatica;* 62 *Podophyllum emodi;* 63 *Asparagus adscendens;* 64 *Curuma zedoaria;* 65 *Abrus precatorius;* 66 *Saxifraga ligulata;* 67 *Datura stramonium;* 68 *Cinaamomum takala;* 69 *Acorus calamus;* 70 *Leucus linifolia;* 71 *Vitex negundo;* 72 *Hyoseyamus niger;* 73 *Verbascum thapsus;* 74 *Zanthoxylum alatum;* 75 *Asparagus racemosus;* 76 *Thalictrum foliolosum;* 77 *Mentha sylvestris;* 78 *Tinospora malabarica;* 79 *Boerhavia diffusa;* 80 *Solanum indicum.*

artificially in 1927 by way of experiment. Since 1939 it has been cultivated on commercial scale, at Bhelab, in the Bhillangna range. The last annual output from this plantation was about 80 mds.

Since the year 1946-47 a contract has been given for the plantation-cum-exploitation of medicinal herbs in the Tehri and Uttarkashi forest divisions. Under this scheme the contractor has to plant 5 acres of each of the important medicinal plants annually. If this succeeds we shall be putting this industry on sound basis.

14. Ringal

Three different kinds of *ringal* (*Arundinaria falcata*, *A. spathiflora* and *A. jaunsarensis*) grow in our oak, *deodar, kail, leur, papri* and fir forests, spreading over a total area of 1,053 sq. miles. It does not, however, mean that all this area is occupied by *ringal*. Perhaps, it will be safer to assume that it grows over one-tenth of this area. One of these varieties is hollow inside and is exported from the State. A second is used for manufacturing matresses for drawing rooms and the third is used for preparing baskets locally.

When bamboo can be used for paper pulp it is just possible that these *ringals* should also give paper pulp and it is well worth finding out the possibilities in this connection.

15. Semla (Bauhinia retusa) Gums

In Saklana Banali and Dhanari and Yamuna watershed low level *kukat* zone a few thousand of *semla* trees occur. Of these tapping for gum has been confined to the Saklana and Banali forests only. The total yield from all these forests could not be more than two to three hundred maunds.

16. Jhula

Moss occurs on oak and other associated species in the sub-alpine zone. This moss is used for the manufacture of a dye and for packing fruits. Last year, a contract for this was sold for the Tehri forest division.

17. Fibres

The trees and plants yielding fibre are *bhimal* (*Grewia oppositifotia*), *bhangla* (*Cannabis sativa*), *kandali* (*Girardinia heterophylla*) and *banskeura* (Agave). Of these, *bhimal* fibre is extensively used in Pargana Jaunpur for the manufacture of matresses and ropes; *banskeura* fibre is used for the above purpose in the Tehri jail. In the Punjab hill states beautiful footwears are made from the fibre of *bhangla*. Locally, fibres of *kandali* are used for ropes and Labanas of Mandi and Suket use these for the manufacture of cloth. All these species do not, however, grow in the forest but in the unmeasured land.

18. Mulberry Plantation and Sericulture

Mulberry (*Morus alba and M. serrata*) grows naturally as scattered trees in different parts of the State, specially in the cooler regions. Artificially, it was attempted to be planted in Simlasu reserve for a number of years. This plantation did not, however, prove successful as illicit grazing and illict grass cutting could not be stopped. Along with this plantation, ova of silk worms were imported and attempted to be cultured and their worms reared at Tehri. This, however, did not go beyond the experimental stage and that too not attempted on proper scientific lines. With mulberry trees naturally growing in different parts of the State, with plenty of forest areas where mulberry plantation can be successfully done, and with climatic conditions quite favourable for the rearing of silk worm and the culture of their ova, there is every possibility of sericulture succeeding in the State. What is required is an expert in the line, with facilities required for the success of such an industry.

19. Lac Culture

We have in our low level *kukat* forests, particularly from Kusheraila to Kaudiyala a few thousand *kusum* (*Schleichera trijuga*) trees on which culture of lac can be introduced. The leaves obtained from lopping of *kusum* trees will provide leaf fodder to the cattle and thereafter good healthy broods of lac can be obtained from outside and their sticks tied to the lopped branches of the *kusum*. The lac produced can then be collected and the operation repeated during a second season of the year. This industry is worth developing. What we require, is again, an expert who knows all about this work.

B. Agriculture.

20. Agricuture—The total area of land under agriculture is 2,25,891 acres consisting of 24,252 acres under irrigation and 2,01,639 acres unirrigated and village sites.

The produce of irrigated land comprise of rice, wheat, barley, mustard, tobacco, potatoes and other vegetables, and pulses such as *urad*, *bhatta* [81] etc.—the main crops being rice, wheat and barley.

In the unirrigated land the produce consists of rice, wheat, *koda* [82], *Jhangora* [83], pulses such as *gath* [84]; *tor* [85], *urad*, *masoor*, *sunta*, and potatoes, *marso* [86] etc.

21. Cereals

This is the main crop produce in both irrigated as well as unirrigated fields and worth taking into account. The only exception is potato which is produced annually up to about 50,000 maunds.

Taking the annual average produce of an acre of irrigated land to be 12 mds. the total quantity of cereals produced in the irrigated land$=24{,}252\times12$ mds.$=2{,}91{,}024$ mds. This is a conservative estimation as yield per acre of irrigated land for Almora district recorded in agricultural statistics, (1936-37) is: rice 1,500 lbs. or 18 mds. and wheat 1,250 lbs. or 15 mds.

Similarly, assuming the average agricultural produce of unirrigated land to be of 11 mds. per acre, the total output from unirrigated land$=2{,}01{,}639$ acres$\times11$ mds. $=22{,}18{,}029$ mds. From this if we subtract 50,000 mds. of potatoes, the net quantity of cereals produced comes to 21,68,029 mds. In unirrigated land in the Almora district the yield per acre is recorded to be : rice 1,400 lbs. or 17 mds. and wheat 1,000 lbs. or 12 mds.

The total quantity of cereals produced in the State is, therefore, 2,91,024 mds.2 +1,68,029 mds. = 24,59,053 mds. annually.

The total population of the State is 4,00,189 of whom we may assume 25,000 to be infants living on milk. So, the total population living on cereals is 3,75,189. The daily consumption of food is $\frac{3}{4}$ seer per head in the State. This gives the consumption of cereals per head to be $\frac{3}{4}\times\frac{365}{40}$ mds. $=6.8$ mds. per annum. The total amount of cereals consumed in the State, therefore, comes to 3,75,189 + 6.8 mds. = 25,51,285 mds. This includes cereals used for seed and for feeding domestic animals.

Taking the above two paragraphs into consideration, the deficit quantity of cereals produced in the State is 25,51,285 mds.—24,59,053 mds.=92,232 mds. or say, 90,000 mds.

The deficit areas are Tehri town, Narendranagar town, Deoprayag town. Kirtinagar town and pattis Panchgain, Fateh Parbat, Adhor, Barasu, Geeth, Wazri, Bamund, Dharakariya, Lostu, Vadivargad, Lassya, Dhungmandar, Dharmandal, Ramoli Round, Bhadura, Ona. Raika and Taknore—the areas underlined obtain cereals from stock imported into the State and the rest from surplus areas within the State.

It has already been mentioned that the amount of potatoes annually produced is about 50,000 mds. This is exported from the State. The other agricultural products which are exported are *mirch* (red pepper) *pindalu*, *kuchain* and *haldi*. The total quantity of these does not exceed a few hundred maunds, and so they have not been taken into account in the aforesaid paragraphs.

Besides, the above quantity of cereals, 2,25,891 acres of land under cultivation yield about $22\frac{1}{2}$ lac mds. of dry fodder annually for domestic animals.

22. Live stock

The domestic animals kept and maintained in the State are bullocks for ploughing the fields, cows and buffaloes for milk, sheep and goats for wool and for transport of cereals and salt, mules and horses for transport and for riding, respectively. The total number of domestic animals under different heads are as below:—

	Buffaloes.	*Cows.*	*Bulls and Bullocks*
Male.	4,240	..	92,812
Cow:	67,913	91,819	..

	Sheep and Goats.	*Mules.*	*Horses.*
Male:	2,10,938	699	677
Cow:	..	..	290 (mares).

Out of 67,913 buffaloes and 91,819 cows we can safely assume that only 30,000 buffaloes and 40,000 cows yield milk annually and the rest remain dry. So, taking the yield of milk

81 *Glycina saja.*

82 *Elusine coracana;* 83 *Optismenus fromentacas;* 84 *Dolichus biflorus;* 85 *Cajanus flevus;* 86 *Amarantus paniculatus.*

per buffalo per day to be 4 seers and of a cow to be $1\frac{1}{2}$ seers on an average and taking their lactation period to be 12 months and 9 months, respectively, the total milk produce of the State $=30{,}000\times4\times365$ seers and $40{,}000\times1\frac{1}{2}\times270$ seers=4,38,00,000 seers plus 1,62,00,000= 60,000,000 seers. Again we can safely assume that 400,00,000 seers of milk are used in the preparation of *ghee*. The quantity of *ghee* produced amounts to 400,00,000 *chataks* or 25,00,000 srs. or 62,500 mds. The milk used for drinking may be taken to be 20,00,000 seers. From this figure we obtain per capita consumption of milk, per day, to be

$$\frac{20{,}00{,}000\times16\times5}{400{,}189\times365}\ \textit{tolas}$$

or 1 *tola*.

The *ghee* is mostly exported and the ordinary villager uses oil, chiefly imported from outside, as it is cheaper.

From 210,938 sheep and goats the annual yield of wool taken at 2 seers per head per annum, on an average, amounts to $210{,}938\times2$ =421,876 seers or 10,000 mds. nearly.

C. MISCELLANEOUS

23. Woollen Industry

In addition to about 10,000 mds. of wool produced locally about 2,000 mds. are imported from Tibet via Jelukhaga, and British Garhwal. From this 12,000 mds. of wool Dumkars, Dhablas, Barmol, Kounts, Bendies and Pankhies are manufactured locally. The Jads of Jadung, Harsil and Bagori are engaged whole-time in this work. In addition, the pattis of Rawain Pargana, Bangar, Ghutto, Thatikathoor and Taknore are engaged part-time.

From 12,000 mds. of wool the total length of woollen cloth prepared may be taken to be 15,00,000 yards of the standard width of 18 inches. The annual consumption of this is about 10 lac yards. So, about 5 lac yards are available for export.

24. Agriculture

We have in the State 2,424 villages. Out of this at least 500 practice agriculture in the old-fashioned way. In a village there are about $\frac{1}{2}$ dozen houses who have one or two beehives. So, at present the total number of beehives in the State may be taken to be $500\times6\times1=3{,}000$. The output per hive per year, may be taken to be one seer of honey. Hence, the total quantity of honey produced in the State amounts to 3,000 srs. or 6,000 lbs. The wax is thrown away but if it is accumulated its total quantity, per year, should be 1,500 seers.

25. Fisheries

The natural species of fish habitating our streams, *Khalas* and *nalas* are *mahasher, rohu* and *ansivala*. Of these, the *mahasher* swims up the valleys in hot weather and returns to warmer waters in the plains in autumn.

Among the exotics we have the brown trout in the Bhagirathi introduced since the last 30 years from hatcheries at Pratapnagar, Kaudiya and Kaldiyani. Of these, the first closed more than 20 years back and the second about six years back. In the remaining Kaldiyani hatchery the total pupulation of the ova-producing trouts is about 200 of different ages. From artificial plantation carried out, these trouts have spread right up to Harsil in the Bhagirathi and have been caught in the waters of the Bhillangna near Tehri. The Dodital, at the top of Kaldiyanis gad, is heavily populated with these trouts. They were planted in the Tons and the Yamuna but these experiments failed.

26. Horticulture

We have in the State apple orchards at (1) Harsil (2) Magra (3) Dhanolti (4) Kanatal (5) Kaudiya and (6) Pratapnagar. The total number of fruit-bearing trees in all these orchards is between 3-4 thousands. At Motibagh, Simlasu and Dayara there are orchards of mangoes and litchies. At Kot-Bungalow citrus species were introduced about 10 years back.

The apples of Harsil are brought down to the Palace at Narendranagar during winter. Due to over-running of the main bloc of this orchard by the flooding of the Jalandri three years back, its yield has been reduced and some of the trees have since died. The Kot-Bungalow and Dayara orchards are under the supervision of the D. F. O's. The rest of the orchards are auctioned and give some revenue to the horticulture department.

26. Hides and Horns

The skins of wild animals collected annually in the State, number less than 100. Due to improper skinning, these reach the range office and head offices in very bad condition. Unless the beat guards are trained in taxidermy there is no possibility of any improvement in this connection.

The skins of domestic animals are collected by divisional contractors who use them locally and a little quantity is also exported.

Horns at present go waste.

27. Poultry Keeping

There is no trade in this with the exception of a few eggs sold off and on at Tehri and Narendrangar and in a few villages. The scheduled caste Hindus and the Muslims keep poultry, mostly, for their own use. And the total number of poultry kept in the State does not exceed a few hundred. There is good deal of demand for eggs and for fowls at Tehri, Narendranagar, Mussoorie and Dehra Dun. So there is scope for development of this industry near about these towns.

28. Import and Export

The chief articles of import are cloth (both cotton and woollen), cereals, salt, iron, utensils, sugar, spices, mustard oil, *gur*, kerosine oil, fruits (dry and green), books, stationery, medicines, boots and shoes, gold and silver, arms and ammunition, furniture, dyes, bangles, paints, varnish, toilet goods, tea, oilman's stores, *biris* and cigarettes, cattle, horses, mules, agricultural implements, motor buses and motor cars, cement, gunny bags, etc.

The exports are timber, *ghee*, butter, cream, milk, potatoes, sticks, *ringal*, medicinal herbs, resin, bullocks and hides. A certain amount of cereals is exported to Tibet *via* Jeu-khaga and to British Garhwal and Jaunsar Bawar.

Taking the annual income from customs to be Rs. 4,00,000 the total value of import and export may be taken to be Rs. 30,00,000. This does not include timber, the value of which can be taken to be about 30,00,000. So, the total value of foreign trade amounts to Rs. 60,00,000 per annum.

AFFORESTATION FOR BENGAL *

By T. M. Coffey, C. I. E., I. F. S.

(Chief Conservator of Forests, Bengal).

First of all I would like to thank you for giving me this opportunity of addressing you on this very important subject. It is a subject which I am interested in myself and it is also one in which the government is very interested.

The first point I would like to remark on is the necessity for afforestation. Apart altogether from the urgent necessity of stopping further soil erosion, Bengal must also make itself self-supporting as regards forest products. At present Bengal is a deficit province so far as the area under forests is concerned. The area of government forest per head of population is only .07 acre. Economists estimate that to be self-supporting in forest products a country should have at least 20 per cent of its surface area under forests. Against this, Bengal has only 9 per cent and a good deal of that is protection forest such as in the delta area and in the Darjeeling hills which must not be exploited. Therefore, there is an all-round shortage of timber, firewood, charcoal, bamboos, and all the other minor forest products which are so essential to a country.

Other provinces are not so badly off. Bombay has 17 per cent, the Central Provinces 23, Madras 15, and the United Provinces 13. The average for the whole of India is 14 and the average for Europe is 26 per cent. I, therefore, think you will agree with me that afforestation in Bengal is both essential and urgent.

The forest department has been urging the government of Bengal for many years to legislate for the afforestation of waste lands and for the conservation of what is left of the private forests. At long last a bill was introduced in the Bengal. Assembly in 1944 for this purpose. Fortunately before the ministry resigned the bill passed successfully through a select committee so the Governor, considering the famine and other calamities which faced the province, was able to make it a Governor's Act, and not postpone legislation any longer. The bill was enacted in August 1945 and, so far as private forests are concerned, and thanks to the co-operation and help of the *zemindars*, I am glad to be able to report considerable progress. The idea of the private forest act is to help the owners put their forests in order; there will be no change in ownership, but, government will have the power and, incidentally, the duty to tell the owner how to run his forests. Government will meet all expenditure for the first ten years, and in certain cases

*Talk delivered to the members of the Rotary Club, Calcutta, on 18th March 1947.

of hardship such as where there is a serious drop in revenue because of conservation, government will make loans to the forest owners. That is the present position about the private forests in Bengal and it can now be said that it is a satisfactory position or at least working up for that. Not so with the waste lands.

The province has millions of acres of cultivable waste land which should be afforested. The exact area is estimated to be 4 million acres, *i.e.*, 9 per cent. of the province or the equivalent of the forest area already under government management. At present all this waste land is rapidly deteriorating in quality, and in some places that I have seen in West Bengal, desert conditions are fast approaching. The only use this land is being put to is to provide grazing (and very poor grazing at that) for thousands of half-starved, more or less useless, cattle. The owners of these cattle are a menace to landowners. They refuse to pay any grazing fees, and when the cattle have cleared the waste lands of every blade of grass they then invade the private forests and eat up all the young seedlings; later on graziers even set fire to the forests so that they may have a nice young crop of grass coming up after the early rains. To my mind these graziers are as bad as any criminal tribe and they constitute a problem which must be faced. So much for grazing. I shall now revert to the waste land problem. All these waste lands were under forest not so very long ago, until with the increase in the population they were deforested and cultivated for a few years until all the surface soil was washed away. They are highlands really, above the paddy field level and should never have been deforested. Now the problem is to get them back under forests as quickly as possible and see that they are never again deforested for cultivation. To do this we feel that there must be change of ownership, in other words that government must acquire the waste lands and reafforest them. The private owners will never reafforest them. With this object in view we started preliminary enquiries some time ago and were informed by some landowners, keen on afforestation, that they would give the land for nothing or practically next to nothing. However, when the time came and acquisition proceedings began the owners wanted fantastic prices. Government perhaps expects to have to pay more than a private individual but to be asked to pay 10 or 20 times what a private person would be asked, is not good enough. We have therefore come to a standstill for the present about the afforestation of these waste lands. This is a very serious thing for the province, the people are crying out for forest produce, and soil erosion of the waste lands will continue unchecked if something is not done. Government have, therefore, been compelled to introduce a new bill called the Bengal acquisition of waste land bill. The object of this bill is to speed up the acquisition of waste lands and to acquire such land at something approaching its proper value. We have forest officer under training at Dehra Dun, Edinburgh and Oxford, so, as soon as this bill is enacted we shall be in a strong position to take up afforestation immediately and in a big way. The idea is to have a forest officer in every district in the Province. At present there are 10 districts with forest officers and 17 without. All that we want now is the land. Government have even provided the money for the afforestation.

The afforestation of these waste lands is not going to be as an easy matter. Some of them are as bare as a rock with which nothing can be done except to try and stop further erosion. All of you know that to grow even the poorest quality grass, even spear grass, that some surface soil is necessary. A tree requires a good deal more. It will not be possible, therefore, to reafforest Bengal in a night. It is going to be a long and tedious job to get these waste lands back into production from the terrible state that they are in now. Some experts think that we are taking on too much and that we are over-optimistic; but we must try. To begin with, we shall have to stop further erosion, particularly sheet erosion, and thus improve the quality of the soil. The climate of Bengal is very much in our favour for this. In this damp, hot climate, vegetation comes in of itself and establishes itself quickly provided it is protected from cattle. As soon as the soil is reclaimed we propose to plant quick growing species suitable for the requirements of the local people such as species for building materials, agricultural implements, firewood, country boats, carts, furniture, fodder grasses, matchwood and paper pulp. The cultivation of bamboos and the conversion of some of the waste lands into grazing grounds is also part of the programme. As grazing will have to be restricted in the private forests it will be essential to grass down some of the waste lands

for controlled grazing. This should help to improve the quality and breed of cattle and reduce the number of useless animals. I should have told you that the estimated area of unculturable waste land in Bengal amounts to the staggerng figure of 18 per cent of the total area of the province. I am afraid nothing can be done about this at present, but we must try and stop any further cultivable waste land from becoming uncultivable.

That is the position to-day. After many years of difficulties and disappointments, lack of policy and lack of legislation, fighting uphill all the time, we have now reached a very interesting stage in forestry in Bengal. The prospects are bright and the future is so full of interest that I feel envious of our successors. The future programme is organised for them and they will have the pleasure of actually putting into practice something which is definitely for the good of the whole country and part of a world-wide programme. They will see waste lands planted up, soil erosion checked, plenty of water in the rivers for irrigation and river communication, and country boats plying their way all the year round as they used to do 20 or 50 years ago before wholesale deforestation was allowed.

A NEW CALLIPER FOR MEASURING DIAMETERS OF STANDING BAMBOO CULMS.

By S D. N. Tiwari, M.Sc.

(Indian Forest College, New Forest, Dehra Dun).

Past records show that there is no satisfactory adjustable calliper for measuring the diameters of bamboo culms standing in clumps. The main requirements of such an instrument are a long handle so that the measurements can be taken of culms inside the clump and secondly, an adjustable arrangement which can be manipulated from outside the clump. The instruments used in the Forest Research Institute for this purpose is a prong with fixed diameters (Fig. I below), which can record only fixed diameter classes. Secondly, a tree

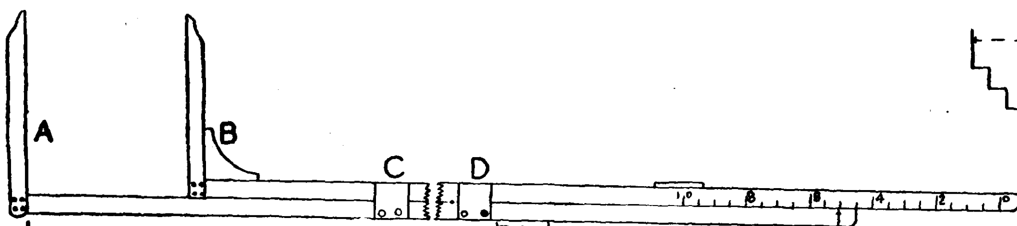

FIG 2

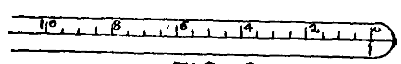

FIG 3

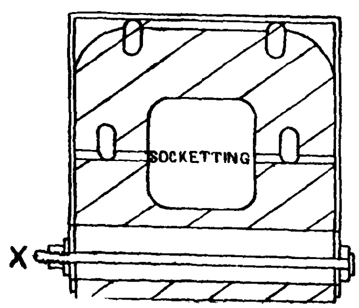

FIG 5

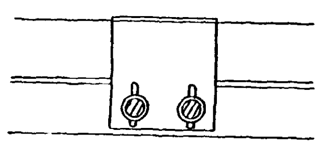

FIG 4

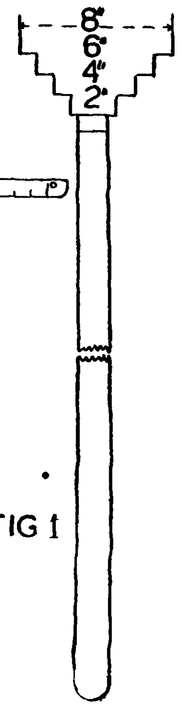

FIG 1

compass described in the Schlich's *Manual of Forestry*, Vol. III, Fig. 4, may be used for this purpose. But its use is very limited owing to its short handles and possible loss of accuracy (as it may not record the mid-diameter). There is a third instrument in the form of an arc with movable arms. Here the mistake is enlarged due to scale being far smaller on the arc than the actual width measured.

In this article a design of a new adjustable calliper is described to measure the diameters of the bamboo culms.

In Fig. 2 above, IF is a main arm 4 feet ×1 in.×0.5 in. with a side arm AI fixed at a right angle to it 6 in.×1 in.×0.6 in. in size. BE is another similar piece except that the length of the smaller arm is about 5 in. This arm is graduated at E in inches and tenths of inches from the end E and also on its lower edge so that it can be read when the calliper arms are holding the culm either on the left or on the right of the main arm (Fig. 3 above). The graduation can be done into finer divisions by the use of a vernier; or into diameter classes according to requirements. The arms IF and BE are held together by metallic clamps C and D in such a way that the arm BE slides freely along IF when the calliper arms A and B are to be opened. When the latter touch each other the pointer reads zero on the scale E (Fig. 3 above). The scale is graduated from right to left so that when arms A and B are separated by 5.2 in. (in Fig. 2) the pointer F reads 5.2 in. at the scale. In short, when the calliper arms A and B are applied round the bamboo culm inside the dense clump, the diameter is read directly at the other end of the calliper outside the clump without removing the calliper. Of course, the calliper arms are applied parallel to the measurer's body and from the side of the culm; and not in the way usually adopted with callipers for measurements of diameters of trees.

M and N are the handles on two arms to facilitate moving of arm BE in and out. The convenient length of the calliper is 4 feet and hence all culms can be measured in clumps with a maximum diameter of 7 feet. On the outside of the arm A, a socket can be provided in order to hold chalk or any other material for marking the enumerated culms.

The accuracy and efficiency of the instrument depends on the hoops C and D. They should be such that the arm BE should slide freely on the main arm IF and at the same time they should remain parallel to each other and completely juxtaposed. Fig. 5 gives a cross section through one of the hoops. The outer rim represents the metallic hoop with about 0.05 in. thickness which is fixed rigidly to main arm IF by means of two nuts and bolts passing through the oblong hole (Fig. 4) so that the hoop can be loosened or tightened by shifting it more towards the outside or inside respectively. In order to reduce friction between the two pieces and against the clamp, the arm BE is beaded on the outside and inside. If due to wear one bead is more worn than the other, adjustment can be done by removing the clamp and by filing off the opposite bead equally.

To make the instrument as light as practicable (at the same time maintaining its strength) the two arms are hollowed out partially on the inside. Further the edges of the arms are rounded off to facilitate free movement of the calliper amongst the culms.

Comparative Merits of the Instrument

(1) It is very simple to construct. One such instrument has been constructed in the Forest Research Institute workshop, tested in the field and found to work satisfactorily.

(2) It can be graduated to give actual diameters down to 1/20 in. correctly (and if a vernier be used more accurate readings can be obtained).

(3) Instrumental error due to wear and tear can be corrected.

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Note by Sri D.L. Sah, M.Sc., B.A. (Oxon.), I.F.S., Principal, Indian Forest College

Sri Tiwari has constructed a handy and useful calliper for measuring the diameter of bamboos standing in clumps but such callipers are likely to be used only by research officers.

THE BAMBOO FORESTS OF RAIGARH STATE

By R. Chakravarti, B.Sc.

SUMMARY: Contains a description of the bamboo forests of Raigarh State in the Eastern States Agency, and discusses problems connected with their management. The quality of bamboo is rather poor, and the area exploited annually is about 35,000 acres and the possible yield about 20,000 tons of air-dry bamboos. Felling cycle is four years and the system of working monopoly-cum-royalty. The bulk of the bamboo is exported to paper mills at Ib. Raniganj and Titagarh. The main sources of damage are fire and grazing.

Introduction

Situation.—Raigarh State is one of the most important states of the Eastern States Agency, lying between 82°57′E and 83°52′E and 21°42′N and 22°33′N and covering an area of 1,482 square miles. The main Bombay-Calcutta line of the Bengal-Nagpur Railway passes from east to west through the centre of the State dividing it into more or less equal halves.

Configuration.—North of the railway line the country is hilly and to the south lies the vast, fertile, open and well populated country locally known as the *Dandaha*. Two distinct ranges of hills are noticed: the Chanwardhal range running east and west in the centre of the state and the Tolge range lying further north in the Ghargoda-Lailunga Tehsil. Between the two blocks lies the fertile, well-populated Ghargoda-Tamnar valley. Linking the two ranges on the west is the Mar block.

The general altitude rises from 800 feet south of the railway line to 1,300 feet in the north. The elevation of Raigarh town is about 700 feet. In the hilly blocks the general elevation is between 1,000 feet and 1,800 feet.

Drainage.—The drainage of the state is taken up by the Mand, the Kelo, the Kharung and the Chote-Kelo rivers which flow to join the Mahanadi a short distance outside the southern boundary of the State.

Geology, rock and soil.—The predominating rock is sandstone which occupies the centre of the state, extending east to west to a width of some 30 to 34 miles. The southern part of the state consists mainly of calcareous shales and shaly limestones, with narrow inliers of quartzite and schist. To the north outcrops of granite-gneiss occur forming a fairly extensive plateau. Coal measures and limestone are found in several places, so also ironstones, which are unimportant, sporadically.

Climate.— Temperature records are not available. Heat in summer which extends from March to the middle of June is oppressive. The winters are cool, but frost is not known to occur. The rains set in by the middle of June and extend up to the middle of October. The average rainfall is 67 inches of which 60 inches fall in June-September.

Forests of Raigarh State

The forests of Raigarh State may be put in three classes, *viz.*, *sal* forests, mixed forests and bamboo forests.

Sal forests.—Areas containing more than 30 per cent *sal* come under *sal* forests. In most cases the percentage of *sal* is high and may be as much as 90 per cent. *Sal* reaches best development in deep sandy loam which is porous and well aerated. Such areas are mostly in Ghargoda and Lailunga Ranges of northern Raigarh. The common associates of *sal* are, *Terminalia tomentosa*, *Boswellia serrata*, *Pterocarpus marsupium*, *Diospyros melanoxylon*, *Anogeissus latifolia*, *Terminalia belerica*, *T. Chebula*, *Madhuca latifolia*, *Lagerstroemia parviflora*, *Cleistanthus collinus*, *Emblica officinalis*, etc., while the shrubs are, *Phoenix acaulis*, *Indigofera pulcherima*, *Nyctanthus arbor-tristis*, *Helicteris isora*, etc.

Mixed forests.—The mixed forests are confined to shallow rocky soils and in certain localities *sal* is completely absent. The most important species found are, *Anogeissus latifolia*, *Pterocarpus marsupium*, *Cleistanthus collinus*, *Acacia catechu*, *Boswellia serrata*, *Terminalia tomentosa*, *Gmelina arborea*, etc. with some *sal* in places. The subsidiary species

are, *Emblica officinalis*, *Soymida febrifuga*, *Semecarpus anacardium*, *Buchanania latifolia*, *Madhuca latifolia*, *Holarrhena antidysentrica*, *Bombax malabaricum*, *Cassia fistula*, etc.

Bamboo Forests

Bamboo forests.— *Dendrocalamus strictus*, Nees, locally known as *saliha bans* is the species growing in Raigarh State. The bamboo does not grow pure in the forests and occurs mixed with deciduous species. It is rare in areas suitable for *sal*. In some blocks (*e.g.* Tolge) it occurs almost as a pure crop with very little undergrowth.

Quality.—The quality of the bamboo is rather poor. The average height is 25 ft. and the average girth 3 inches. In favourable localities bamboo as high as 50 feet with a girth of 6 inches may be met with. Stunted crops are met with in poorer localities where there has been much maltreatment in the past, and where there is a dense canopy of broadleaved species. According to their size the bamboos of Raigarh State are classified into three quality classes.

Generally the bamboos growing in dry localities though smaller in height and girth are solid or nearly so. It is also believed locally that the bamboo growing in the Rabo block is not susceptible to attack by white ants.

In many localities the soil is so poor that it is fit only for the growth of bamboo and a few deciduous species, and cultivation would be impossible. In fact, there is evidence of cultivation having been attempted in the past and then abandoned. Agriculture in the same area would have brought in only a small fraction of the returns produced by the bamboo.

About three hundred green bamboos of Raigarh quality go to make a ton.

II

New culms.—New culms begin to appear at the outbreak of the monsoon, that is, by the beginning of July. The popular belief that a thunderstorm is essential for new culms to appear exists in Raigarh State.

New culms continue to appear up to the end of August or even later and the culms complete their growth by the end of October. Generally they spring up at the periphery of the clump and by successive repetition of the process the clumps sometimes get separated into two. The average age of the individual culm is believed to be six to seven years in Raigarh State.

Regeneration. There is no record of the dates of sporadic flowering in Raigarh State. The last sporadic flowering occurred in 1940 and the resultant seedlings form a dense undergrowth in some blocks. Their careful bringing up is a problem of paramount importance in Raigarh State.

It has been recorded that natural regeneration of bamboos is thick in *sal* areas. This seems to be in conflict with the statement above that the bamboo is rare in areas suitable for *sal*. The probable explanation is that the bamboo grows quite well in deep sandy loam favoured by *sal* wherever it can get it, but is quickly ousted by *sal* which forms a thick canopy over it.

No experiments ever seem to have been conducted in this state on the regeneration of the bamboo—either artificial or natural. Natural regeneration from seed has already been referred to. Rhizome and culm cutting have some times been tried on the annual 'Arbor-day', but very little success has been achieved. This is probably due more to the fact that the people at large have not become 'forest conscious' and to lack of protection against grazing than to anything else.

Regarding the clearfelling of clumps and subsequent regeneration, the following instances, casually observed, may be of interest, no regular experiments having been conducted.

(*i*) A forest earth road was being aligned during the summer through the forest and all the growth consisting of scattered deciduous species and bamboos cut flush with the ground, not uprooted, and covered with six inches earth on the average. After the first showers of the monsoon, along with coppice shoots of deciduous species new culms of bamboo also came up. They were rather thin.

(*ii*) During summer carters passing through forest roads sometimes cut (illicitly) whole clumps of bamboo. The leaves provide fodder for their cattle and a variety of uses could be found for the bamboo. The stumps left, as may be expected, are rather high. After the monsoon the stumps gave slender whippy shoots with dense foliage; and some new culms more slender than the normal, were observed.

(*iii*) In one block (Basnajahr), notorious for highly congested clumps (owing to maltreatment and very heavy grazing), the contractor

was permitted, as a special case, to clearfell the clumps leaving high stumps. The new culms that came up were not appreciably different from normal culms. It would be interesting to know how these developed subsequently.

Coppice felling and bamboo growth.—As bamboos occur mixed with deciduous species, both are worked side by side, the latter under a coppice with standards system and the former as will be described later on. During the coppice fellings, the bamboo clumps are not felled. It would be interesting to know if there is any relation between coppice fellings and the subsequent bamboo growth, and whether the latter is influenced by the former, in view of the fact that the overhead cover is removed during the coppice fellings and bamboo in common with most of the grasses prefers plenty of overhead light.

III

System of management.—The bamboo forests of Raigarh State are worked on four years' cycle. Till 1944, about 75 per cent of the bamboo forests had been leased out for 12 years on a monopoly-cum-royalty system to the Bharat Sabaigrass, Limited, with a minimum annual royalty of Rs. 22,000. Since September 1944, however, a fresh lease also for 12 years for the remaining areas has been taken up by the Bengal Paper Mill Company, Limited, on the same terms but with a minimum annual royalty of Rs. 1,5000. Prior to this the unleased areas used to be divided into annual coupes of varying acreage and sold by public auction. Though this brought in greater annual returns financially, it was found to cause more harm than good, since the coupe contractors were not usually interested in the forests after their year was out and the standard of work was consequently low. The lease-holders on the other hand had to work systematically and according to the rules if they expected a good yield from the coupe when they would return to it four years later. Further the long-term lease-holders had scope to effect other improvements, such as transport

Royalty.—Royalty is assessed on extraction which is checked at the lessee's recognized depots mostly near the stations, subject to the condition that extraction keeps pace with

The royalty is Rs. 1/4- per hundred bamboos from areas close to the railway station and Re. -/12/- from areas far removed from the Railway station. Royalty for stumps and top portions, if extracted, is assessed at eight annas per cartload and for purposes of calculation of royalty the full length of bamboo is counted as 24 feet.

Cutting rules.—The following cutting rules are observed:

(*i*) All shoots to be cut within one foot from the ground level or in any case not higher than the second internode.

(*ii*) No culms which are two years old and less than two years old are to be felled.

(*iii*) All dead, top-broken and badly malformed culms are to be removed *unless they are of the first year's shoots.*

(*iv*) Out of the green culms only fully matured culms will be removed in such a way that not less than five culms of more than two years are left evenly distributed over the whole clump.

(*v*) No clumps containing less than ten shoots are to be worked.

Besides, the contractors are encouraged to avoid leaving the top of cut bamboos in the clump, thus making it top-heavy and increasing damage from fire. Entire bamboos should be pulled out. High stools are generally left in the case of culms adjoining a new year's shoot.

Contractors are discouraged from making use of strips of young bamboos for bundling, etc. Side by side with cutting they are recommended to 'prune off' the branches, giving the stroke from bottom upwards, even in the case of culms retained in the clump in order that the future working of the clump may be rendered easy.

The average area exploited annually for bamboo in Raigarh State is about 35,000 acres.

Local Sales.—The lessees usually work the forests to feed the paper mills. But there is also a very large demand locally in Raigarh and the adjoining states, *zamindaris*, and districts of British India for purposes to be detailed later on. It has always been a problem to satisfy both the local and the paper pulp demand. Formerly permits were issued to the local purchasers and they were allowed to go into

found to be very unsatisfactory, since for every bamboo the purchaser cut he destroyed or damaged many others; and his cattle did untold damage to the forest. Now that almost all the bamboo areas have been leased out, the problem of local sale has become acute. If permits were continued to be issued it would mean the infringement of the lessee's 'exclusive right' to extract bamboos. Further the permit-holders will interfere with the system that the lessee might be following and it will be difficult to assess who did the damage.

Departmental working of the forest to sell to the local purchasers also presents difficulties because in such cases, the department will have to work simultaneously in several small scattered areas.

A working arrangement exists at present whereby the lessees are required to satisfy the local demands fully before exporting the bamboos for paper pulp. The lessee cuts the bamboos and stocks them in recognized depots and sells them at rates fixed by the State to *bona fide* residents of Raigarh State for their own use. It cannot be claimed that this system is working to the satisfaction of both parties since the contractor is not really anxious to satisfy the local demand and the local purchasers complain that the contractor gives them an inferior type of bamboo. One advantage of this system is however that the purchasers are not allowed to go into the forest and cut the bamboos for themselves. The contractor, incidentally, is supposed to sell bamboos of average quality to the local purchasers.

Labour.—Labour is not usually difficult to procure and is cheap unless there is some departmental work of magnitude in progress close to the bamboo coupes. The cutters use rather light axes with small blades; but the use of heavy axes with long blades which would go cut inside the clump is being encouraged. Actually if the lessee could procure axes of the right type and lend them to the cutters during the working season, matters would greatly improve.

It is considered advisable to have two parties of coolies, one in charge of cleaning the clumps and the other immediately following the first, and in charge of the actual cutting.

It was formerly the habit of the lessee to appoint sub-contractors and work through them. This was found to be unsatisfactory and the lessee now appoints his own supervising staff.

Transport.—The only means of transport in Raigarh State for forest produce until recently has been bullock or buffalo carts. They are generally easy to procure (except when they are engaged in the transport of foodgrains). In hilly blocks, the bamboos have to be dragged to the nearest cart track by coolies or buffaloes. Recently lorry transport has been introduced wherever possible. The state contemplates extensive road construction in all important forest areas and a ten-year programme has been drawn up. On the other hand contractors are expected to make their own drag paths and minor extraction roads.

The rivers Mand and Kelo are floatable for a short period after the monsoon, but very little use is made of this facility.

Before extraction the bamboo is cut into pieces of about 6 feet in length and made into bundles of 25 pieces.

Costs.—The approximate cost of working is as follows. The figures are for 1944.

per 100

Cutting	.. ..	Re. 1	0	0
Dragging	.. ..	Rs. 1	8	0
Carting				
up to 10 miles	.. ..	Rs. 1	8	0
10-15 miles	.. ..	Rs. 4	0	0
Cutting and bundling	..	Re. 0	6	0
Local supervision	.. ..	Rs. 0	4	0
Other expenses	.. ..	Rs. 0	6	0
Royalty	.. ..			
leased	.. ..	Rs. 1	4	0
unleased	.. ..	Rs. 2	0	0

Railway freight.

per ton of air dry bamboo

Bengal Paper Mill	.. ..	Rs. 11	0	0
Titaghur Mill	.. ..	Rs. 14	0	0
Orient Mill	.. ..	Rs. 3	0	0

The average cost works out to be Rs. 23 per ton at the railway station, excluding loading charges which come to about Rs. 5 per wagon, and railway freight.

A conservative estimate of the annual yield of bamboos of Raigarh State would be 60 to 70 lakhs, or say 20,000 to 25,000 tons of air dry bamboos.

IV

Damages.—Damages to bamboo in Raigarh State may be classified as follows.

1. *Man.*—Man does by far the greatest damage. The young bamboo shoots are known locally as *karil* and are prepared into curry or chutney fresh or pickled into *hedua*. Both are highly relished and during the monsoon the damage done is considerable. Besides this rhizomes are sometimes dug up to make walking sticks. Illicit cutting and faulty cutting (high stumps, etc.) also deserve a mention here. Man is also responsible for the next two types of damage, *viz.*, fire and illicit grazing.

2. *Fire.*—Damage to forests by fire is really serious in Raigarh State. The myth of rolling stones and friction of bamboos as causing fire finds wide belief even among enlightened forest staff, but the cause of many a fire is a carelessly thrown *beedi* or *chungi* or the fire spreads from an adjoining field where the cultivator has been burning litter, or has been setting fire under a *mahua* tree for the sake of the flowers. After the working season the floor of the forest is strewn with refuse and these dry materials quickly spread the fire in summer.

3. *Grazing.*—In spite of grazing rules, illicit grazing does take place to an alarming extent. The damage done by wild animals such as spotted deer and *sambhar* is negligible when compared to the damage done by domesticated animals. Heavy and clumsy animals like buffalo cause further damage by bending and breaking the young shoots.

4. *Animals.*—Apart from damage by grazing already referred to, further harm is done by cutting for fodder, especially in summer, by the passing carters. Whole clumps are sometimes cut as already stated. Monkeys relish young shoots and the damage done by them and by porcupines and rats is by no means inconsiderable.

The ghoon beetle.—In a growing bamboo, the liability to attack by insects and fungi seems to be negligible in Raigarh State. The chief enemy of cut bamboo is the *ghoon* beetle (*Dinoderus* sp). Large quantities of bamboos are made unsound within a few weeks of their cutting. It has been suggested that cutting should be confined to winter months to reduce liability to attack by *ghoon* beetle; but with large areas to tackle this seems to be an impracticable proposition as also when the bamboo is required urgently and at all seasons for paper manufacture. Immersion in water has good results. A single coating of oil and creosote by the 'rub on' method had doubtful results, especially at places where the bark had been removed as at the ends of uprights required by the Ordnance Department.

V

Uses.—The uses to which the bamboo is put are manifold and are as follows, as far as Raigarh State is concerned.

As already mentioned young bamboo shoots, either in the fresh state or pickled into *hedua* are much relished and every year many maunds of these are illicitly extracted and exported. In seeding years the seeds are ground into a flour and made into *chapatis.*

All sizes of bamboos are used in most details of construction, especially in the poor man's house. Tender bamboos, say of the second year, are woven into baskets and mats. It is always difficult to reconcile the demands of the weavers with those of silviculture especially when the mats and baskets are in demand in large quantities, as for example during the war. The interests of local industries should not be stifled and when normal conditions return it will probably be possible to allow the extraction of a limited quantity of second year shoots for the weavers.

The chief use to which the bamboos of Raigarh State are put is for conversion into paper-pulp and almost the entire quantity available is exported to the paper mills.

Though bamboos are not popular as fuel they are sometimes used, especially the refuse left in the forest after felling. Bamboo charcoal is used by goldsmiths. I have seen the stumps being used as the legs of cheap country cots.

Conclusion

The bamboo is one of the main items of forest produce in Raigarh and with increased care and intensity of management the bamboo forests of the State have a great future. While laying due stress on the necessity for management based on sound silvicultural principles two points seem to merit special attention, *viz*, protection from fire and grazing, both of which form the principle menace to the bamboo

forests of Raigarh. The fire hazard can be considerably reduced if no refuse material is left lying against or suspended in the clumps. Refuse material lying on the forest floor may be cleared by early burning in winter, say during November-December-January. Early burning should be made a joint responsibility of the department and the contractor. Grazing should be rigidly controlled and the number of cattle that could be grazed should be carefully assessed and this should be followed by the introduction of rotational grazing. Blocks where regeneration is coming up should be strictly closed to grazing.

As already mentioned bamboos require plenty of overhead light and the provision of light in forests where it occurs mixed with other species is no easy matter. But the canopy could be opened out by the thinning out the more useless deciduous species wherever possible.

If the bamboo is to have a stable market, it should be increasingly used for paper pulp and the import of foreign paper pulp should be discouraged. The price of the bamboo should be controlled so that the middle man may not have the biggest share of the cake. The above should not however blind us to the fact that the aim of any sound forest management is to satisfy the demands of the local population who live in the forests and for whom the forest exist. Their demands should be fully met with before export is contemplated. The village wastelands should wherever possible be planted with bamboo, and the plantations should be made the property of the village community whose representatives should be made responsible for their careful bringing up and exploitation. Local industries involving the use of the bamboo should be encouraged as part of rural uplift and in all cases success can be achieved only by the willing co-operation of the local people, which can be secured by removing their prejudice and ignorance through intelligent propaganda.

THE INFLUENCE OF FOREST TYPES ON THE DEGREE OF PODSOLIZATION.

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Opinions among pedologists have often differed as to the role of vegetation in soil-forming processes. Some have considered[1] vegetation as being a dependent variable, while others have approached the problem dialectically before assigning to it the role of a dependent or independent variable[2]. The subject-matter of this paper is to discuss in the light of the available works the influence of forest types on the degree of podsolization. It is confusing that some pedologist like Vageler, as quoted by Mohr[3], has postulated the occurrence of podsols in the tropics under conditions of extreme humidity, although none has been reported as yet by tropical workers. According to the climatic theory on the vertical zonality of soil groups, podsols are likely to occur, especially on the acidic rocks, in the cold regions of the high mountains in the tropics. Mohr[3] points out that in addition to the above factors, the vegetation must be of the type conducive to the occurrence of podsols in the tropics. He states further that in New Guinea above 10,000 ft. presumably there exists the best chance for the occurrence of podsols, but thus far none have been found there.

Jenny[2] says, "A danger exists in the definition of podsolization as being simply leaching or eluviation, since hardly a soil exists that would not, under this too liberal interpretation, be considered as podsolized. The concept would thus lose its significance as a fundamental classification criterion." He further points out that the extensive podsol studies of Mattson and his associates emphasize the need for supplementing field observations with detailed chemical investigations.

A clear understanding of the influence of forest types on the degree of podsolization needs a careful study of ecology, climatology, intensity and period of weathering, etc. It is now admitted, however, by all pedologists that podsols occur under humid conditions and are best developed in cold to temperate regions. Moreover, the podsols and their congeners are completely leached soils in which Ca CO_3 and $CaSO_4$ are present only as fugitive

constituents. The reaction is thus on the acid side of neutrality.

Podsols are classified under zonal soil grounds, having a "climax type of vegetation" as one of their characteristic features. We should not confuse the so-called "climax type of vegetation" as one capable of living forever under a particular type of environmental conditions. A "climax type of vegetation" should be considered not as a permanent type, but as one that has been the most successful and the least variable in the course of its competition for existence with the other plants under the existing material (*i.e.* environmental) conditions. Moreover, such a climax type is also subject to replacement, during the formative stages, by another type which will be the climax under the new environment that may come into play. Theoretically, mixed stands of the two climax types are also possible during the transitional phase, *i.e.* in passing from one climax type to the other.

In all studies of podsol soils the process of podsolization has been associated with the soil organic acids and organic matter in general. Ramann, Dokuchaev, Sibirtzev, Glinka, in their early works and a number of other investigators stressed the role of organic acids in the process of podsolization. An examination of pH of a large number of podsol profiles over a wide geographical area shows that the pH in A_2 horizon is usually between 3.8-4.5, thereby demonstrating the development of the bleached grayish-white eluvial horizon under acid-leaching conditions. Robinson[1] points out that an acid reaction is not in itself sufficient to cause podsolization. This may be shown in the laboratory by allowing one-tenth normal solutions of hydrochloric and oxalic acids separately, to percolate through ferruginous sand. Although the pH of hydrochloric acid is lower than that of oxalic acid, the solvent action of the latter is considerably greater and quickly leads to bleaching by removal of ferric oxide. Thus we see that it is not only the acidity but also the nature of the substances causing acidity that should be taken into account.

The occurrence under the same climatic conditions and on the same parent material, of brown podsolic soils and podsols in hardwoods and coniferous forest stands, respectively, as well as the occurrence of faintly developed podsols undermixed hardwoods and conifers has created much interest among pedologists and foresters in general. The works of Chandler[4], Joffee[5], Wilde[6], and a number of European workers stress the fact that relatively high-calcium species retard podsolization, while relatively low-calcium species favour podsolization.

Chandler[4] arbitrarily divides the forest trees into three groups on the basis of the calcium content of their foliage. The "soil improvers", or high-calcium species, have an average calcium content in excess of 2.0 per cent in their foliage. The "soil depleters", or low-calcium species, contain less than 1.0 per cent of calcium in their foliage. The intermediate group contains from 1.0 to 2.0 per cent of calcium in their foliage. The readers are referred to in his paper that contains the calcium analysis of the foliage of 27 forest-tree species.

As a rule, the hardwoods contain a higher ash and calcium content in their foliage than the conifers, and even the wood and bark of the hardwoods have a higher ash content than the wood or bark of the conifers. But it should be pointed out that not all coniferous trees are low in calcium and not all deciduous trees are high. Red cedar and white cedar, both members of the Pinaceae, are high absorbers of calcium. Among the deciduous trees that are low in foliar calcium content are beech and red maple. On a typical podsol in the Adirondack mountains, the trees consist predominantly of *picea rubra*, with scattered specimens of *Betula lutea*, *Abies balsamea*, *Acer rubrum*, *Fagus grandifolia*, *Tsuga canadensis*, etc.

Forest litter is the raw material of humus formation in the forest. The main source of forest litter is generally the leaf and needle-fall from the trees, and the pH of the soil in case of both hardwoods and conifers depends upon the calcium content of the leaves added to the forest floor. Of all the basic constituents making the ash of the forest litter, calcium is perhaps the most important. This element influences the process of podsolization through its effect on the degree of base saturation, the activity of nutrifying bacteria, the rate and degree of incorporation of organic matter into the soil, the physical properties of the soil, etc. Certain of these effects are only indirectly related to the calcium content of the litter. Other bases of course, act similarly, but evidence indicates that the influence of calcium

outweighs that of all the other bases combined. This is owing in part to the relatively large amount of calcium present as well as to the nature of the cation.

It may be worthwhile to mention here the effect of percentage base saturation and localities on the absorption of calcium by the same species of trees. The works of Chandler[4] and other workers point out that the relative order of calcium content of the foliage of the species would not change greatly if trees of the same species were sampled in various regions. Chandler[4] found that if the soil is 50 per cent or more saturated with bases in the surface soil, the amount of calcium absorbed is not affected; but where soils are 20-30 per cent base-saturated, a reduction in the calcium absorption seems to occur. The species that normally absorb relatively large amounts of calcium, however, are not generally found occurring abundantly on very acid soils.[4] As the soil gets more and more acid, the high-calcium species tend to drop out, and the low-calcium species increase in that proportion.[4]

Hardwood litter, usually because of high-calcium content, decomposes much faster than the conifer litter, and the pH in the surface soil of the former is higher. Hardwoods in general give mild humus ("mull" type) consisting of mixed organic and mineral matter. Conifers, on the other hand, give rise to acid humus layer ("mor" type), usually matted or compacted, or both, distinctly delimited from the mineral soil unless the latter has been blackened by the washing in of organic matter. There are fewer intermediary split products of decomposition from hardwood litter than from coniferous litter, and the final products of mineralization in the hardwoods being basic in reaction contribute to the retardation of podsolization process. In the richer, coarser "mull" types, the leaves that fall one autumn are almost entirely disintegrated and incorporated into the mineral soil by the next leaf-fall period, especially through the activities of earthworms. The forest litter from conifers, on the other hand, poor in basic constituents, undergoes a type of decomposition, chiefly through the action of the fungi, resulting in the production of a layer of acid peaty organic matter which, in the almost complete absence of earthworms, remains sharply differentiated from the mineral soil over which it lies.

This sharply differentiated organic matter of "mor" type may mislead one to make a high estimate of organic matter content as compared to the "mull" type, although both may occur in the same region. The following data, taken from Romell[7] and Morgan and Lunt,[8] show the effect of environment of the same region on the organic matter content of "mull" and "mor" types of humus.

Region	*Depth of sampling*	*Type of humus layer*	*Total organic matter in Kgms per sq. meter*
Sweden [7]	1 meter	Crumb mull	28.7
		Fibrous mor	27.9
New Hampshire, U.S.A. [8]	40 inches	Rich crumb mull	57.8
		Thick podsol (grease mor)	62.1
Connecticut, U.S.A. [8]	40 inches	Crumb mull	24.9
		Thin podsol (granular mor)	30.4

It seems from the above table that there is little difference in the organic matter content of the two types of humus layers under the state of dynamic equilibrium in the same region. However, one cannot completely exclude the possibility of a certain average difference between mull and mor in amount of accumulated organic matter. It is now becoming popular among the forest scientists to classify forest soils on the basis of humus layers, ground vegetation, or existing forest stands, each of which seems to be more or less characteristic of the particular soil type.[9]

The brown podsolic soils are agriculturally quite important and they are being utilized extensively for grain and dairy farming. The podsols are of little agricultural importance but they have found their place in lumbering enterprise and in the manufacture of several by-products from timber. The forest scientists are interested in maintaining forest soils in a high state of productivity. This can be done to a certain extent, apart from proper silvicultural practices, through selection and stand-improvement of those species that help to maintain or increase the fertility of the soil;

maintaining at the same time the forest stands of economic importance.

The opening up of forest soils, occurring especially in the very wet tropics, for agricultural enterprise, needs careful consideration. The existing forest stands may not necessarily tell the potentiality of the fertility level of soils on which they occur. In general, forest soils are more leached than those under grass stands, and when such soils, paricularly in the very wet tropics, come to equilibrium with their environment in course of their genesis, the cycle of growth continues mainly through the use of nutrients that are locked up in the forest stands and liberate on decay of the fallen forest leaves, twigs, etc. [3, 10]. Such soils, when opened up for agriculture, seem to decline rapidly in reproductive capacity after a few years of cultivation unless regularly manured or fertilized. Pendleton, in a recent lecture at Cornell, also mentioned this point that when soils under forest stands in the relatively high rainy sections of Brazil and adjoining Latin American countries were cleared and put under the plough, they declined in fertility quite rapidly, and it was necessary to use manure or artificial fertilizer to grow successful crops. This is an important point to be kept in mind when the evaluation of the farming potentialities of forest soils of high rainfall areas may be necessary for a readjustment of our lands that should be distributed among forests, pastures and cultivated crops in balanced and judicious proportions for maximum use of our soils in a high state of productivity.

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IN MEMORIUM
(NILAMBUR TEAK PLANTATIONS) 1846–1946

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Amidst the tall, and stately teak trees standing aloft in their mature splendour, in the 1846 teak plantation (Elenjeri Compartment 33, Nilambur forest division) there stands a small tablet which reads:—

> "This plantation of 1846
> commemorates the work of Mr. H. V. Conolly, Collector of Malabar, under whose orders between 1841 and 1855, the first 1,500 acres of the Nilambur plantations were formed.
> The earliest stone in the foundation of systematic Forest Management in India".

The year 1946 marked the centenary of the oldest plantation available in Nilambur to-day. But the first attempt to plant teak goes to an earlier date, 1841. The energetic beginnings of Mr. Conolly have resulted in the formation of extensive teak plantations of to-day and these plantations, area for area, form one of the most valuable timber forests of the world. In Nilambur to-day one finds the text-book conception of a normal forest with a complete and regular succession of age *gradations*, the like of which is perhaps nowhere available for *long* rotations.

The value of these plantations is enormous as will be realized from the past yields and the price obtained to-day for teak makes one feel that these plantations are worth their weight in gold. Under the present working plan for the Nilambur division teak is artificially regenerated under two working circles. The plantation working circle, is 6,591 acres in extent comprising (1) first rotation teak plantations formed between 1863 and 1912 and (2) second rotation teak plantations formed between 1917 and 1937. The conversion working circle is 25,535 acres in extent where

clearfelling of suitable natural forest and concentrated artificial regeneration of teak in areas suitable for the species is being carried on. There are few localised patches where teak has failed and others where miscellaneous plantations are being raised. The area under pure teak *to-day* is about 4,500 acres under plantation working circle, and about 3,200 acres under conversion working circle, *i.e.*, about 7,700 acres are under pure teak to-day. Every year the teak plantation at rotation age (70) in the plantation working circle and about 150 acres of natural forest in conversion working circle are clearfelled and planted with teak. The present annual planting programme includes about 220 acres annually. Thus while about 60 to 70 acres of old plantation is clearfelled and replaced with teak, the teak area under conversion working circle is extending gradually by about 150 acres annually. (The areas given are gross areas). At present investigation of fresh areas for growing teak is being carried on.

The Origin

It would perhaps be of interest to foresters all over the country to recollect on the occasion of the centenary of Nilambur plantations, the origin of these valuable plantations.

The old province of Malabar was wrested from Tippu Sultan in 1792. When Tippu's usurpation ceased, the local rajas claimed possession of lands and forests near their *zamins* (lands). Nothing was done by the government at that time to prevent this. The result was that the government had under its possession an infinitesimal proportion of forest lands, in the beginning of the 19th century. At that time large demands for teak were made by Bombay dockyard. The forests of Kanara and Malabar were the chief sources of teak supplies. Fellings went on rapidly and the private owners left their forests in a devastated state over large areas. The government forests, small in extent, could not meet the demand fully; at the same time they were anxious about permanency of supply. In 1828 Mr. Sheffield, Collector of Malabar, drew the attention of the government to prohibit the indiscriminate felling of teak. Nothing was done until 1840, when Mr. Conolly, Collector of Malabar, commented on the poor condition and small extent of teak available at that time. He thought that the acquisition of forests was necessary to meet the increasing demand. He arranged to execute leases with some private owners of forests for this purpose In the meanwhile, he was successful in prohibiting the removal of immature teak. But the acquisition of forests did not go a long way to meet the demand, since they were in a devastated state, with all the good teak already exploited. So in 1843 Mr. Conolly wrote:—

> "I do not think it is advisable to make any more purchase of land unless under very favourable and peculiar circumstances. So long as immature teak is not cut, it is of little matter to whom the ground on which it grows, belongs. .... The only case in which it seems absolutely necessary that the government should come forward to take the initiative is in the formation of new forests, to replace those which have vanished from private carelessness and rapacity—a work too new, too extensive and too barren of early return to be ever taken up by the native proprietors."

Early History

Thus Mr. Conolly appreciated not only the importance of conserving teak, the imperative need to put an end to removal of mature teak, the necessity to prevent the forests of private owners going into a devastated state, but also, at the same time, realized the importance of augmenting the supplies of natural teak by artificial regeneration. And thus Mr. Conolly holds the pride of place in Indian forestry being the pioneer in planting teak.

Due to his untiring efforts, the first attempts to sow and transplant teak began in the year 1841. The early experiments between 1841—1843 were beset with the usual obstacles and difficulties of the beginnings of any great enterprise. But the work was carried on with firm determination. In the year 1843 Mr. Chatu Menon was appointed as sub-conservator and he set about the task of clearing and planting with great zeal and enthusiasm. Mr. Chatu Menon had to contend many difficulties, fever and frequent scarcity of provisions. Yet he appears to have never left the plantations and took the greatest pride in the success of his plantations. In fact the more or less continuous extension of these plantations to the present day is indirectly attributable to Mr. Chatu Menon's integrity and honesty. If the laudable intentions of Mr. Conolly laid the first step in the systematic forest management in India, it was the untiring efforts and hard work of Mr. Chatu Menon which brought the early plantations into shape.

Present State

Such is the history of the origin of the valuable teak plantations of Nilambur. To-day one can see in Nilambur acres and acres of teak plantations standing on the characteristically undulating ground amidst a net work of streams, rivers and rivulets with patches of cultivation scattered in between. The young fully stocked woods which are growing with their youthful vigour are an impressive sight indeed. The work began a century ago is still being carried on and is gradually and steadily increasing in extent where by the building up of a new series of teak woods by converting natural forest, is in progress.

If, with pardonable pride, Nilambur holds its head high in planting practice and growing of teak, it is in no small measure due to the energetic beginnings of Mr. Conolly and the indefatigable energy of Mr. Chatu Menon who have left behind them the greatest legacy among our national assets. Standing at the important milestone in the progress of Indian forestry, on this occasion of the centenary of the memorable beginnings of teak plantations in India, let us take our hats off to Mr. Conolly and Mr. Chatu Menon for their splendid work and the parting legacy they left behind to our nation!

EXTRACTS

DECOMPOSITION STUDIES WITH DIFFERENT TYPES OF COMPOST IN THE SOIL.*

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During the course of pot-culture experiments with crops carried out in this laboratory, with a view to comparing the manurial behaviour of composts prepared by different methods, it was noticed that the degree of crop response was influenced not merely by the C/N ratio of the compost applied, but also by the nature of the waste material used in the preparation of the compost. Thus, for the same C/N ratio of the final manure, composts prepared from night-soil and town refuse were found to be more effective, per unit of nitrogen, than composts prepared from resistant farm wastes, *e.g.* sugarcane trash. As it was inferred that this difference in crop response must have been primarily due to the difference in the rate of liberation of available nitrogen in the two cases, it was considered advisable to carry out systematic experiments in the laboratory in order to compare the rates of ammonification and nitrification of composts prepared under varying conditions and from different types of waste material.

The experiments were carried out by mixing weighed quantities of the manure with soil and incubating the mixture under optimum conditions of moisture and temperature for definite periods of time, after which the total carbon and nitrogen as well as ammonical and nitrate nitrogen present in the sample, were determined. Fuller details of the experimental procedure are given below.

Materials and Methods

The soil used for the present experiments was a red loam obtained from the Experimental Farm attached to the Indian Institute of Science, Bangalore, which analysed as follows:

Table I

Analysis of soil used

Mechanical composition		Chemical composition	
	Per cent.		Per cent
Coarse sand	33.4	Total carbon	0.59
Fine sand	26.4	„ nitrogen	0.058
Silt	7.7	„ P_2O_5	0.02
Clay	26.4	„ K_2O	0.22
Moisture	3.84	„ Lime (CaO)	0.10
Loss on ignition	3.19	Silica (SiO_2)	77.76
Carbonate	*nil*	Iron and alumina ($Fe_2O_3+Al_2O_3$)	13.75
pH	6.2		

It would be noted that the soil contains average amounts of carbon and nitrogen for Indian red loams, but is poor in phosphoric acid.

For the decomposition studies, weighed amounts of well-powdered, dry composts were added to 100 gm. portions of the soil in 250 c.c. wide-necked bottles, mixed thoroughly and incubated at 28°-30°C., after adjusting the moisture content to about 50 per cent of the water holding capacity, by the addition of distilled water. About 18 c.c. of water

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were required in the present case for each 100 gm. portion of soil. The loss of moisture during incubation was made up by fresh additions of distilled water every alternate day, and the mass was well stirred after each such addition, in order to ensure better distribution of moisture and aeration. Care was taken to add just enough water to bring the soil to a good tilth and to avoid clogging and anaerobic conditions due to excess of moisture. It was found that a visual check to ensure the above condition was more effective than weighing the bottles each time.

At the end of definite periods (2, 4, 8, 12 and 20 weeks) duplicate bottles were removed from the incubator and the whole of the contents were carefully scraped out and transferred into wide porcelain dishes to dry. The last traces of adhering soil and salts were washed out from the sides of the bottle with a small quantity of distilled water. The soil mass in the porcelain dish was dried in an incubator kept at 45°-50°C. and when dry was taken out and kept in the laboratory for a day in order that equilibrium with the air might be achieved. The air-dry weight of the mas was determined, after which it was powdered and aliquots were taken for the determination of moisture, organic carbon, total nitrogen ammoniacal nitrogen and nitrate nitrogen. Organic carbon was determined by the chromic oxidation method of Acharya [1936], total nitrogen by the Gunning modification of Kjeldahl's method [A.O.A.C. 1935] ammoniacal nitrogen and nitrate nitrogen by Olsen's method [1929]. Changes in organic matter are expressed in terms of carbon and all values have been calculated in terms of the total quantities present in the experiental samples taken.

Decomposition of soil organic matter

Since in the present studies the decomposition of the organic matter present in the soil is likely to be superimposed on the decomposition of added compost material, a set of preliminary experiments was carried out in order to follow the course of decomposition of the organic matter originally present in the soil and to test the influence of factors such as addition of lime or phosphate or diluting the soil with sand. Four sets of bottles were run—one set with soil alone without the addition of any chemicals; the second set with soil mixed with 100 gm. of washed quarty sand; the third set with soil mixed with 5 gm. of calcium carbonate; and the fourth set with soil mixed with 100 gm. of sand and 0.5 gm. of potassium phosphate (K_2HPO_4). The other details relating to incubation and analysis were the same as given in the last paragraph and the results obtained are presented in Table II.

Table II

Carbon and nitrogen changes incubated soil.

Materials added	Incubation period.	Total organic carbon in mg.	Total nitrogen in mg.	Ammoniacal nitrogen in mg.	Nitrate nitrogen in mg.	Total available nitrogen in mg.
I. 100 gm. soil without any addition of chemicals	Initial	590	58.0	*nil*	0.80	0.80
	2 weeks	606	61.2	0.52	1.20	1.72
	4 ,,	632	63.0	0.80	1.60	2.40
.. ..	8 ,,	624	64.2	1.20	2.40	3.60
	12 ,,	616	62.4	1.00	3.20	4.20
	20 ,,	598	60.2	0.80	2.60	3.40
II. 100 gm. soil +5 gm. calcium carbonate	Initial	590	58.0	*nil*	0.80	0.80
	2 weeks	608	62.2	0.32	1.20	1.52
	4 ,,	644	66.6	0.60	2.60	3.20
..	8 ,,	626	61.4	0.80	3.80	4.60
	12 ,,	606	59.6	0.60	3.60	4.20
	20 ,,	586	57.2	0.30	1.80	2.10
III. 100 gm. soil + 100 gm. sand	Initial	590	58.0	*nil*	0.80	0.80
	2 weeks	618	62.4	0.80	1.40	2.20
	4 ,,	636	64.8	1.40	2.80	4.20
	8 ,,	644	63.1	1.20	3.40	4.60
	12 ,,	612	60.8	1.00	3.80	4.80
	20 ,,	602	59.2	0.60	2.10	2.70
IV. 100 gm. soil + 100 gm. sand +0.5 gm. K_2HPO_4	Initial	590	58.0	*nil*	0.80	0.80
	2 weeks	624	63.6	1.40	1.40	2.80
	4 ,,	652	68.4	1.80	2.80	4.60
	8 ,,	638	65.6	2.00	3.60	5.60
	12 ,,	622	63.4	1.60	4.20	5.80
	20 ,,	596	56.6	1.00	2.80	3.80

Carbon and nitrogen.

On incubating the moist soil at 28°-30°C. there occurs in the first four weeks appreciable fixation of carbon and nitrogen from the atmosphere. • The fixation is somewhat helped by the addition of lime or sand to the soil and is markedly improved by the addition of potassium phosphate. Under optimum conditions, the fixation of carbon amounts to about 10 per cent on the initial value and of nitrogen to about 18 per cent. The maximum values are generally reached at the end of four weeks. Similar data have been reported by Basu and Vanikar [1942].

The simultaneous fixation of carbon and nitrogen is explicable as being due to the rapid development of a nitrogen fixing algal flora in the soil [De, 1939; Allison and Hoover, 1935]. This algal flora is, in the second stage, probably attacked by bacterial leading to the loss of both carbon and nitrogen.

The complication which this process of natural nitrogen and carbon fixation taking place in soils creates in interpreting data obtained on the decomposition of organic manures added to the soil, does not appear to have been emphasized by workers in the field. The degree of ambiguity caused in the present case is set out in Table III, wherefrom it would be seen that the quantities of carbon and nitrogen added to soil by natural fixation amount to about 40-60 per cent of the quantities normally added in the form of compost manure (at the rate of 10 tons of dry manure per acre which is equivalent to about 1 gm. of manure per 100gm. of top soil).

TABLE III

Nitrogen and carbon in soil with and without manure

	Carbon in mg.	Nitrogen in mg.
I. Originally present in 100 gm. soil	590	58
II. Added in 1 gm. of dry compost per 100 gm. of soil representing 10 tons of dry manure per acre. ..	120	10
III. Carbon and nitrogen fixed by 100 gm. of soil without manure in four to eight weeks (Table II). ..	40.60	6..8
IV. Available nitrogen (i.e. ammoniacal nitrogen + nitrate nitrogen) produced in the above soil in 8.12 weeks under optimum conditions (Table II). ..	..	4.6

While studying the carbon and nitrogen changes undergone by compost or other organic manure mixed with soil, one therefore meets with two different systems working simultaneously—one being the fixation processes taking place in the soil and the other being the decomposition processes occurring in the added manure. Since these react in opposite directions, the overall balance of total carbon and total nitrogen present in the system at any particular stage, would give no measure of the extent of decomposition undergone by the added manure. It is difficult to obtain values for the decomposition of the manure alone by deducting from the observed values the 'control' values for the incubated soil, since there is considerable interaction between the manure added and the fixation taking place in the soil; in other words, the carbon and nitrogen fixing capacity of the soil is markedly influenced by addition of organic manure.

Though the total carbon and nitrogen values of the soil-cum-organic manure system do not possess, from the scientific standpoint, any definite interpretative value, they possess considerable bearing on the 'practical' side, as indicating the 'overall' result that may be expected to occur in the field, when organic manures such as composts are applied to the land. From this point of view, it was considered worthwhile to include the total carbon and total nitrogen determinations in the experiments reported in this paper.

It would be noted from Table II that after the fourth week, both carbon and nitrogen values of the incubated soil show a progressive decrease and at the end of 20 weeks they recede back to the initial values.

The changes in ammoniacal and nitrate nitrogen of the incubated soil are of the usual recognised type. There is an accumulation of nitrate in the system for a period of 8 to 12 weeks, after which there is loss of nitrate, probably in the gaseous form. The total 'available' nitrogen, including in this term both ammoniacal and nitrate nitrogen, reaches a

maximum at the end of 12 weeks, after which it shows a rapid fall. The quantity of 'available nitrogen, formed is slightly increased by the addition of lime or sand to the soil, and is markedly increased by the addition of potassium phosphate.

Preliminary trials with nitrogenous materials

Before undertaking studies relative to the decomposition of composts, it was considered advisable to test for the presence of an active microflora in the soil capable of bringing about rapid decomposition of added organic materials and nitrification of the ammonia produced. For this purpose, preliminary-trials were carried out by adding to the soil various nitrogenous organic materials such as activated sludge, dried blood, egg albumin, hongay-cake, night-soil and cattle dung, and carrying out incubation for 4 to 12 weeks. It is unnecessary to present the data so obtained, but they showed the presence of an active microflora in the soil, which brought about carbon decomposition, ammonification and nitrification.

Decomposition of composts

A large number of samples of composts prepared by different methods in connection with the work reported elsewhere [Acharya, 1939 and 1940] were used in the present decomposition studies, but in order to avoid repetition of data obtained for similar types of composts, only such data are presented as have a direct bearing on the three important factors referred to at the head of this paper as possibly influencing the rate of nitrification of composts, *viz.* (*a*) nature of waste material used, (*b*) C/N ratio of the compost, and (*c*) method of preparation.

In order to obtain a wide range of necessary samples, three methods of composting were tried, *viz.* (*a*) aerobic method, with turnings every fortnight for three months; (*b*) hot fermentation method in trenches [Acharya, 1939 and 1940]; and (*c*) plastering the compost mass in trenches with mud paste from the beginning, without any subsequent turning, which for convenience of denomination cou'd be styled 'anaerobic'. Method (*a*) gave products of the narrowest C/N ratios and (*c*) the widest. By applying these three methods to different types of refuse, *e.g.* (i) night-soil and town refuse, (*ii*) farm refuse containing cattle dung and urine, and (iii) farm refuse poor in nitrogen, *e.g.* sugarcane trash, it was possible to obtain a series of composts, prepared from different types of waste material, possessing C/N ratios varying from 10 : 1 to 30: 1. Fuller particulars of the composts so prepared are given in Table IV.

Table IV

Nature of composts used in the decomposition studies

List No.	Nature of original refuse.	Method of composting	Analysis on dry basis		C/N ratio.
			Carbon per cent.	Nitrogen per cent.	
A	Compost from town refuse and night soil.	Aerobic, in heaps overground ..	11.45	1.08	10.6
B	Do. ..	Hot fermentation in trenches ..	15.62	1.26	12.4
C	Do. ..	Anaerobic, in trenches ..	18.81	1.14	16.5
D	Compost from mixed farm refuse .. (leaves, weeds, dung, urine, etc.)	Aerobci, in heaps overground ..	9.27	0.82	11.3
E	Do. ..	Hot fermentation in trenches ..	13.63	0.96	14.2
	Do. ..	Anaerobic, in trenches ..	17.17	0.81	21.2
G	Compost from sugarcane trash ..	Aerobic, in heaps overground ..	9.83	0.64	13.8
H	Do. ..	Hot fermentation in trenches ..	11.80	0.69	17.1
I	Do. ..	Anaerobic, in trenches ..	17.70	0.53	33.4

Enough of the manure was added in each case to supply 20 mg. of nitrogen per 100 gm. of soil. The results obtained are set out in Table V.

TABLE V

Carbon and nitrogen changes during the decomposition of composts in the soil

Manure No.	Nature of compost	C/N ratio	Period of incubation	Total carbon in mg.	Total nitrogen in mg.	Ammoniacal nitrogen in mg.	Nitrate nitrogen in mg.	Total available nitrogen in mg.
A	Town refuse + night soil, compost, aerobic.	10.6	Initial	802	78.0	*nil*	0.80	0.80
			2 weeks	761	75.2	2.24	1.20	3.24
			4 ,,	744	73.1	2.02	4.46	6.48
			8 ,,	752	76.0	1.40	9.14	10.54
			12 ,,	786	76.4	1.20	7.20	8.40
			20 ,,	772	76.2	0.80	5.26	6.06
B	Town refuse + night soil, hot fermentation.	12.4	Initial	838	78.0	*nil*	0.80	0.80
			2 weeks	799	76.2	1.80	1.04	2.84
			4 ,,	766	74.8	2.42	2.76	5.18
			8 ,,	764	77.6	2.02	7.64	9.63
			12 ,,	783	80.2	1.44	8.74	10.18
			20 ,,	798	82.6	1.02	7.58	8.60
C	Town refuse + night soil, anaerobic	16.5	Initial	920	78.0	*nil*	0.80	0.80
			2 weeks	893	77.3	1.24	*nil*	1.24
			4 ,,	862	76.7	2.04	2.22	4.26
			8 ,,	841	78.4	1.84	5.78	7.62
			12 ,,	822	81.6	1.26	7.56	8.82
			20 ,,	808	83.4	0.96	7.22	8.18
D	Mixed farm refuse compost, aerobic	11.3	Initial	816	78.0	*nil*	0.80	0.80
			2 weeks	791	76.6	1.86	1.24	3.10
			4 ,,	774	74.2	2.04	3.62	5.66
			8 ,,	766	78.4	1.80	6.96	8.76
			12 ,,	882	79.2	1.42	7.22	8.64
			20 ,,	794	80.5	0.94	6.46	7.60
E	Mixed farm refuse hot fermentation	14.2	Initial	874	78.0	*nil*	0.80	0.80
			2 weeks	841	77.2	1.46	*nil*	1.46
			4 ,,	819	75.4	1.84	2.56	4.40
			8 ,,	801	79.2	1.46	5.86	7.32
			12 ,,	796	81.8	1.64	6.24	7.88
			20 ,,	811	83.6	1.22	5.02	6.24
F	Mixed farm refuse anaerobic	21.2	Initial	1014	78.0	*nil*	0.80	0.80
			2 weeks	972	78.6	*nil*	*nil*	*nil*
			4 ,,	933	80.1	0.82	0.26	1.08
			8 ,,	899	81.3	1.24	1.92	3.16
			12 ,,	868	82.6	1.46	3.22	4.68
			20 ,,	831	84.2	1.02	4.68	5.70
G	Sugarcane trash compost, aerobic	13.8	Initial	866	78.0	*nil*	0.80	0.80
			2 weeks	834	76.2	1.24	*nil*	1.24
			4 ,,	809	75.6	1.68	1.34	3.02
			8 ,,	798	77.4	1.84	3.66	5.50
			12 ,,	789	78.6	1.64	4.88	6.52
			20 ,,	798	80.8	1.24	5.24	6.48
H	Sugarcane trash compost, hot fermentation	17.1	Initial	932	78.0	*nil*	0.80	0.80
			2 weeks	901	77.2	*nil*	*nil*	*nil*
			4 ,,	873	78.2	1.24	0.68	1.92
			8 ,,	848	79.6	1.64	1.88	3.52
			12 ,,	829	81.4	1.82	3.42	5.24
			20 ,,	819	83.0	1.24	3.84	5.08
I	Sugarcane trash compost, anaerobic.	33.4	Initial	1258	78.0	*nil*	0.80	0.80
			2 weeks	1162	78.2	*nil*	*nil*	*nil*
			4 ,,	1074	78.8	*nil*	*nil*	*nil*
			8 ,,	998	80.2	0.86	*nil*	0.86
			12 ,,	938	82.4	1.64	0.80	2.41
			20 ,,	882	84.6	1.84	1.48	3.32

Changes in total carbon

The figures presented in Table V show that though the initial quantities of carbon present in the soil-cum-compost systems A to I varied greatly from 800 to 1260 mg., there was a tendency for the carbon figures to come down rapidly to a stable level round about 780-800 mg., this level of 780-800 mg. carbon corresponds to a C/N ratio of about 10 : 1 and is in agreement with the known comparative stability of soil humus which exhibits a similar C/N ratio.

Changes in total nitrogen

There is a decrease in total nitrogen in the first few weeks of decomposition, especially in cases where the initial C/N ratio of the manure is narrower than 15 : 1, after which there is a period of progressive increase in total nitrogen, due presumably to fixation from the air. The fixation is inappreciable in cases where the C/N ratio of the compost is near 10 : 1, but it increases markedly as the ratio gets wider. Thus, in the case of composts F and I (Table V), whose C/N ratios are wider than 20 : 1, the final nitrogen content of the soil-cum-compost system at the end of 20 weeks is about 8 per cent higher than at the start.

A comparison of the data presented in Table V against that presented in Table II would show that the addition of compost of C/N ratio narrower than 15 : 1 delays the start of the natural nitrogen fixation processes occurring in the soil by about 4 to 8 weeks. After the above interval, fixation of both carbon and nitrogen from the air start taking place progressively. In cases where composts with C/N ratios wider than 15 : 1 are added, the above lag period in nitrogen fixation is considerably lessened, but even in such cases, the overall fixation of nitrogen (2 to 4 mg.) is less than in the case of soil alone (6 to 8 mg. Table II). The lower fixation in presence of added compost may be due to the fact that the nitrogen level of the soil rises from 60 mg. nitrogen per 100 gm. soil to 80 mg. nitrogen on the addition of compost ; and at the higher level, the tendency for further nitrogen fixation may be lessened. It is also possible that loss of nitrogen may take place from the decomposing compost and thus decrease the overall nitrogen fixation figures.

Changes in available nitrogen

The data presented in Table V show that the rate of liberation of 'available nitrogen' (ammoniacal plus nitrate nitrogen) and the total quantity liberated, vary inversely with the C/N ratio of the added material—the narrower the C/N ratio, the greater are the rate and quantity of available nitrogen produced.

Comparing the present data with the figures given in Table II for soil alone, it would be seen that except in the case of composts F and I, which possess C/N ratios wider than 20 : 1, in other cases the application of composts has proved beneficial in increasing the quantity of available nitrogen produced in the soil. Compost H with a C/N ratio of 17 : 1 is on the marginal line, the quantity of available nitrogen produced being almost the same as in the untreated soil. Compost F with a C/N ratio of 21.2 shows an initial period of depression of available nitrogen extending over the first eight weeks, after which the system becomes 'normal' and equal to the untreated soil. In the case of compost I (C/N ratio, 33.4), the period of depression extends over more than 20 weeks'.

It is evident from the above that composts F, H and I with C/N ratios wider than 15 : 1, would not react beneficially on crop growth, but on the other hand, may react harmfully by depressing the formation of available nitrogen in the soil, unless a long period of decomposition, extending over four to six months, is allowed to elapse before the succeeding crop is put in.

Influence of method of preparation on the rate of decomposition

A perusal of the data presented in Table V would indicate that the method of preparation of compost exerts its influence on the rate of decomposition of the manure in the soil, mainly by way of controlling the C/N ratio of the compost prepared. Thus the aerobic method, involving several turnings given to the material gives a product of the narrowest C/N ratio, while the hot fermentation method gives products of somewhat wider C/N ratios and the 'anaerobic' method, as described in this paper, gives products of the widest C/N ratios. The nature of the waste material determines also to a certain extent the C/N ratio of the compost prepared. Thus, compost G, prepared aerobically from a resistant type of waste material such as sugarcane trash, possessed a wider C/N ratio (13:8) than compost B (12:4) prepared from town refuse and night soil by the hot fermentation process.

Comparing composts A, B, D, E and G, all of which possess C/N ratios lying within the range 10 : 1 to 14 : 1 it would be noticed that the total quantity of available nitrogen produced in a period of 8 to 12 weeks is maximum in the case of composts A and B pepared from night-soil and town refuse. Composts D and E prepared from mixed farm wastes including leaves, weeds, dung and urine, give somewhat lower values, whereas compost G. prepared from sugarcane trash, shows the lowest value. It is noteworthy that though compost G has a C/N ratio (13.8) narrower than that of E (14.2), still it shows a poorer performance than the latter.

The present data offer an explanation for the better crop response obtained by the writers from night-soil-town refuse composts in pot culture experiments as compared to other types of composts, even though the C/N ratios were more or less similar in all cases.

Discussion

The results presented above would indicate that the two important factors which control the rate of release of nitrogen in an available form from compost manure are: (i) the C/N ratio of the manure and (ii) the nature of the original waste material or starter used for compost-making. The actual method of preparation of compost exerts only an indirect influence by controlling the C/N ratio of the final product obtained.

Of the above two factors, the first one relating to the influence of C/N ratio of a material on the rate of liberation of ammoniacal nitrogen has been already examined in detail by workers in the field. Richards *et al.* [Hutchinson and Richards 1921; Rege, 1937; Richards and Norman, 1931] found that when the nitrogen content exceeded about 1.6 per cent on the dry basis, the material contained in general more nitrogen than what was actually needed for its microbial decomposition and the excess was set free in the form of ammonia. Expressing the above results in terms of C/N ratio it may be stated, that when the C/N ratio was narrower than 25: 1, the material usually liberated a portion of its nitrogen in the form of ammonia, when subjected to microbial decomposition.

The above relationships apply mainly to plant materials which are unfermented to start with. The present experiments with composts go to show that composts possessing C/N ratios narrower than 15 : 1 tend to liberate 'available nitrogen' and thus to increase soil fertility while composts possessing wider C/N ratios tend to absorb 'available nitrogen' from the soil, and thus to decrease, soil fertility though temporarily. To ensure a satisfactory rate of release of 'available nitrogen' from the very early stages of decomposition, it would be preferable to have the C/N ratio of the compost narrower than 12 : 1.

As regards the second factor, *viz.* the influence of the nature of the original waste material or starter used for compost making on the rate of liberation of 'available nitrogen' from the compost, its importance does not appear to have been stressed by previous workers in the field. The general view at present is that when plant materials of diverse composition undergo microbial decomposition, they yield ultimately a more or less similar type of humified material—a ligno-protein complex, with a C/N ratio near 10 : 1 and possessing definite properties Waksman, 1938]. But it is well known that the final product obtained is not homogeneous, but is a complex mixture consisting in the main of two groups of substances, *viz.* (*a*) unattacked residues of the original plant materials and (*b*) synthetic and degradation products of microbial metabolism.

The quantitative distribution of the nitrogen originally present in the refuse or starter, between the above two groups (*a*) and (*b*) in the ultimate compost has not received much scientific attention. It is suggested by the authors that the variation in the rate of release of available nitrogen from composts possessing similar C/N ratios, noted in the present paper, may be accounted for by the differential distribution of nitrogen between the above groups (*a*) and (*b*). Thus, in the case of a compost prepared from sugarcane trash and dung, it is possible that a large part of the nitrogen present in the compost may belong to the group (*a*), representing resistant proteins of the original trash not broken down by the micro-organisms, whereas in the case of composts prepared from night-soil or from cattle wastes or from succulant material such as leaves and grass, a good portion of the final nitrogen of the compost may be microbial nitrogen belonging to the group (*b*). It has been found [Waksman, 1931] that microbial nitrogen is readily ammonified and nitrified.

Further work is being carried out by the authors in order to devise methods for estimating quantitatively the two groups (*a*) and (*b*) present in different types of compost material and comparing the rates of liberation of available nitrogen from them.

SUMMARY

1. The course of decomposition of composts, prepared under varying conditions, when added to soil has been followed, with special reference to changes in carbon and in ammoniacal, nitrate and total nitrogen.

2. The influence of the following factors on the course of decomposition has been examined:

(*a*) method of composting—aerobic, hot fermentation and anaerobic;

(*b*) C/N ratio of the compost, and

(*c*) nature of the original waste material or starter used in preparing the compost.

3. A red loam garden soil, used in the present experiments, when incubated without the addition of compost, was found to fix about 6 to 8 mg. nitrogen from the air per 100 gm. soil, corresponding to about 10-15 per cent of the initial nitrogen content of the soil. With regard to carbon, there was an initial period of fixation from the air, followed by progressive loss in the later stages.

4. In the soil-cum-compost system there generally occurred an initial period of nitrogen loss, followed by a longer period of nitrogen fixation from the air. The extent and duration of the initial loss of nitrogen was found to be greater, the narrower was the C/N ratio of the added compost. When the C/N ratio was wider than 15 : 1 the loss of nitrogen was negligible; on the other hand, appreciable fixation of nitrogen from the air occurred. The total quantity of nitrogen fixed by 100 gm. of soil was, however, less in the presence of added compost than in its absence.

5. When composts of varying C/N ratios were added to the soil, the rate of loss of carbon was greater in the case of materials of wider C/N ratios, and in about 20 weeks, a more or less similar carbon level corresponding to a C/N ratio of about 10, was rapidly reached in all cases.

6. The rate of liberation of 'available nitrogen' (ammoniacal plus nitrate nitrogen) in the soil-cum-compost system, depended mainly on two factors, viz. (*a*) the C/N ratio of the compost added—the narrower the C/N ratio, the quicker and greater was the liberation of available nitrogen; and (*b*) the nature of the original waste material or starter used in the preparation of the compost. Thus, composts prepared from night soil and town-refuse or from cattle wastes were found to liberate a greater proportion of available nitrogen than composts prepared from resistant types of farm wastes, such as sugarcane trash, though the C/N ratios of the composts were about the same in all the cases.

7. The method of preparation of compost—aerobic, hot fermentation or anaerobic—influences the rate of liberation of 'available nitrogen' only indirectly by controlling the C/N ratio of the manure obtained by the method in question.

8. It is concluded that for securing a rapid liberation of available nitrogen and thus obtaining increased crop yields, composts should preferably be prepared from mixed wastes, part of which should be rich in nitrogen, *e.g.* nightdung, soil, Urine, Cattle slaughterhouse wastes, etc., otherwise special organic or inorganic nitrogenous starters should be added while preparing the compost. The final C/N ratio of the compost should preferably be narrower than 12 : 1.

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AGE AND VIGOR CLASSES IN RELATION TO TIMBER MARKINIG

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Classified growth tables designed to guide timber marking are presumed to indicate growth possibilities *after cutting*. The biological characteristics of each tree class are presumed to be the cause of rapid or low growth. Experience in the Southwest points to much confusion between cause and effect. Large crowns have been regarded as a necessity for rapid growth, whereas they are really an effect of the same factor that produces rapid bole growth, namely, *soil moisture as determined by ground space.*

Several ponderosa pine growth table classified according to the Keen system of age-and-vigor classes have been made during the past decade. Without exception these tables show a declining growth rate with increasing age and a rising grow rate with increasing "vigor" (effective crown size). The methods employed in compiling these tables, the underlying philosophy, and the application to management have been such that I have registered my protest in two articles (6,7). The original investigations which led to the development of the maturity selection method of cutting were made in virgin stands. Most obvious of errors is the assumption that growth relationships in virgin stands hold after the stands have been opened up by cutting. Equally gross assumptions have been made in analyzing measurements in cutover stands. Studies of the latter kind are the principle object of discussion in this article.

Classifying the Trees

Since both age and crown size are determined by quick observation and estimate, often with the crown partially hidden, the classification can make no claim to accuracy. Blackjack groups known to be essentially even-aged have been listed by experienced classifiers as containing age classes I, II, and III. Within each crown class is a range of 20 to 25 percent[1] in effective crown length; allowance must also be made for lack of symmetry, thin or short foliage, dead limbs, and anything which is thought to lower the leaf area. It is not surprising therefore to find wide divergence in classifications of the same stand by two observers.

A common error, particularly in dealing with cutover stands, is to assume that a tree remains in the same "vigor" class indefinitely. Trees classified today are assumed to have been in the same class 20 or 30 years ago. Class A trees owe their large crown size to having grown up with abundant space for both crown and root development. The roots extend far beyond the crown spread, and if other trees occur within 50 feet root competition ensues. As the trees grow in size they require more and more root space, even though dominance may insure full exposure to sunlight. What was once an abundant moisture supply now becomes deficient. Encroachment of younger trees within the root zone makes further inroads upon a fixed water supply. The crown size gradually decreases from class A to class B and then to

[1]Crown length by Keen (2) system: A over 55 per cent; B 30-55 per cent; C 10-30 per cent; D under 10 per cent. Keen system as modified in the Southwest (10): AA over 70 per cent; A 55-70 per cent; B 35-55 per cent; C 20-35 per cent; D under 20 per cent.

class C; diameter growth falls off not because the crown is too small but because the moisture supply is no longer sufficient to sustain rapid growth. The table maker puts this tree into class C and points to the current low growth rate as a characteristic of that class, whereas he is really dealing with a class A tree which is succumbing to root competition. The same thing happens when a tree is injured or falls prey to disease which reduces the live crown area. Records at Fort Valley have shown that, after cutting, when small-crowned but healthy trees are freed of competition, the train of changes starts in the opposite direction. Barring disease or injury, there is only one explanation for small crowns in ponderosa pine—crowding. Trees in groups readily show the effects of mutual shading overhead but the even more intense underground competition is less apparent. When groups are well opened up, the response in diameter growth of those remaining is immediate or nearly so; acceleration does not wait until a large crown has formed but precedes crown development, whence it may be inferred that crown growth is an effect rather than a cause. Yet the table maker 20 years later puts such trees into class A or B and credits their rapid growth to one of these classes.

Cutover areas in the Fort Valley Experimental Forest contain many examples of both processes. A former III-AA dominant was classified in 1939 as III-B. Most of the large blackjacks in the edges of groups and now classed as B were formerly in class C, but were released on one side by the cutting of large yellow pines outside the groups. Striking examples of recovery are the relatively small trees which by the form of the crown and the presence of stumps show that they were once overtopped D trees; they are now in class C or approaching B and have grown 1.5 to 2 inches per decade almost from the year of cutting.

Average Diameter Growth

The invariable practice is to average diameter or volume growth in each of the 16 Keen classes. Mass averaging is one of the most effective means of obscuring the truth regarding individuals. The exceptional specimens, which are the very ones to be studied, are buried in a mass of figures. Granting that the timber marker must learn to recognize types, the fact remains that the Keen classes are too heterogeneous to serve the purpose. Briegleb (*1*) has pointed out that the growth of individuals within a class varies widely. If he had carried his studies far enough he would have found that these variations are definitely related to causes other than crown size or age.

Table 1 lists all the trees in typical large blackjack group of 29 trees within an area of 160 acres, logged in 1909 by group selection and again in 1939 by a method called "favoring subordinates" (9). Data for each tree "include age-and-vigor (classified in 1939 by Thomson), position (X= isolated, O=outside of group, M=marginal, I=interior), release, and diameter growth 10 years before and 5 years after the second cutting. Low diameter growth during the decade of 1929-39 indicates that the stand as a whole was overcrowded. As far as can be ascertained, there is no difference in growth rate between age classes II and III; all would be classed as blackjacks nearing the intermediate stage or transition from blackjack to yellow pine. Disregarding age, there were before the 1939 cutting 2 trees in class A, 9 in class B, 15 in class C, 1 in class D, and 2 dead. Of the A trees, both were marginal; of the 9 B trees, 2 were outside, 6 marginal, and 1 interior; of the 15 C trees, 1 was outside (placed in C because of mistletoe), 5 marginal, and 9 interior; the one D tree is marginal (placed in class D because of squirrel damage). Since 1939, one of the C trees has gone into class D because of squirrel damage.

A simple arithmetical average of diameter growth by "vigor" classes before the second cutting gives the usual relationship except that the margin in favor of A trees is small because none are isolated. Arranged with respect to position, the highest diameter growth generally occurs in isolated (X) trees, followed in order by O. M. and I; exceptions in this case are due to the fact that of the three O trees two were heavily mistletoe-infected, being cut for that reason, and one I tree had an unusual amount of space. But, notwithstanding a slower *average* diameter growth for class C trees, 5 of them were among the 11 fastest growers in the group, and one (No. 2231) topped the entire list. After the second cutting, 6 class C trees were among the 10 which grew 0.8 inch or more in five years. Class D trees in the lower half of the grade are admittedly below par as to leaf area and they are often in a pathological condition.

TABLE 1.—DIAMETER GROWTH OF INDIVIDUAL TREES IN AN OVERSTOCKED BLACKJACK GROUP ON AN AREA LOGGED IN 1909 AND AGAIN IN 1939. NO CUTTING WITHIN GROUP IN 1909; 10 OF THE 27 TREES WERE CUT IN 1939

Tree no.	Age-and-vigor class 1939	Position[1] 1939	Notes[2] 1939	Release or cut 1939	D.b.h., inches 1929	D.b.h., inches 1934	D.b.h., inches 1939	D.b.h., inches 1944	Diameter growth 1929-39	Diameter growth 1939-44
									10 yrs.	*5 yrs.*
2213	II-B	M		Good	18.8	19.6	19.9	21.1	1.1	1.2
2214	III-B	M		Cut	26.6	27.1	27.8	..	1.2	..
2215	III-B	O		Good	22.7	23.2	23.2	24.5	1.2	0.6
2216	III-C	M		Good	18.4	18.9	19.4	20.3	1.0	0.9
2217	III-C	M		Good	17.2	17.8	18.4	19.8	1.2	1.4
2218	——	——	Dead		9.6	Dead—suppression				
2219	III-C	I		Light	20.8	21.1	21.5	22.0	0.7	0.5
2220	III-B	M		Cut	24.0	24.7	25.3	——	1.3	——
2221	II-B	M		Good	20.8	21.1	21.6	22.7	0.8	1.1
2222	II-A	M		Light	25.1	25.6	26.1	27.0	1.0	0.9
2223	III-C	I		Cut	21.2	21.6	21.9	——	0.7	——
2224	III-C	I		Cut	18.2	18.5	18.5	——	0.3	——
2225	III-C	I		Good	22.0	22.6	23.1	23.7	1.1	0.6
2226	II-C	I		Good	15.0	15.4	16.0	16.8	1.0	0.8
2227	III-B	M		Cut	25.6	26.2	26.8	——	1.2	——
2228	III-C	M		Good	20.9	21.3	22.1	22.9	1.2	0.8
2229	II-C	I	*Sq.*	Light	15.5	15.6	15.9	16.2	0.4	0.3
2230	III-C	I		Cut	21.1	21.3	21.4	——	0.3	——
2231	II-C	I		Good	14.6	15.4	16.4	17.6	1.8	1.2
2232	III-C	I		Cut	22.9	23.5	23.6	——	0.7	——
2233	III-A	M		Light	28.0	28.6	29.2	30.0	1.2	0.8
2234	III-B	M		Light	23.4	24.0	24.4	25.1	1.0	0.7
2235	III-C	O	*M*	Cut	23.5	23.7	23.9	——	0.4	——
2236	III-C	M		Light	22.3	22.7	23.3	24.0	1.0	0.7
2237	III-D	M	*Sq.*	Light	18.0	18.3	18.6	19.1	0.6	0.5
2238	——	——	Dead		17.6	Dead—mistletoe & bark beetle				
2239	III-B	O	*M*	Cut	22.5	22.8	23.3	Cut	0.8	——
2240	III-C	M		Good	26.9	27.5	28.2	29.5	1.3	1.3
2241	III-B	I		Cut	26.7	27.2	27.4	——	0.7	——

Volume of group, 1929, 11,462 board feet.
Volume of group, 1939, 12,799 board feet.
Volume of group, 1939, after cutting 7,238 board feet (43 percent cut).
Annual increment, 1929-39, 134 board feet, 1.17 percent.
Annual increment, 1939-44, 175 board feet, 2.42 percent.
[1] O=outside group, M=marginal, I=interior.
[2] M=heavy mistletoe, *Sq.*=severe squirrel damage.

The last statement calls to mind another abuse in the usual practice of computing average growth by crown classes. If a tree has lost a substantial portion of its foliage through disease or injury, it is automatically placed in a lower class. Thus when an A or B tree suffers crown deterioration from the effect of lightning or mistletoe, it goes into class C or D. Admittedly, such trees are in a low state of vigor and growth is usually zero; but to place them in the same class with normal C or D trees lowers the average of the class as a whole and subjects the normal trees to unfair discrimination. An extreme example of the effects obtainable by this process appears in an article by Thomson (*10*) based on a large Fort Valley sample plot. In Thomson's Table 1, class D trees average higher on volume than class A trees in all fourage classes; average defect in D trees is 40.6 per cent and net increment is negative. A true class D tree—*i.e.*, one which has grown and remained in class D in consequence of crowding—is seldom over 14 inches d.b.h. and rarely contains heart rot. The only way in which such a tree can attain a diameter of 30 inches and acquire a high percentage defect is to make its major growth as an isolated or dominant class A or B, then decline to class D as a result of disease or injury. Diseased, injured, and dying trees of all crown sizes should be placed in a class by themselves under a designation such as "abnormal" or "dying." The tragedy of averaging growth data is that the final results miss completely the fact that

the better type of trees in class C and class D, when released, may become the fastest growers, and that each one has the potential value of several A trees.

Application in Forest Practice.

All western foresters are presumed to be familiar with maturity selection which undertakes to cut or leave trees according to growth capacity as indicated by age-and-vigor growth tables. The practice has been extensively used in national forests and Indian reservations, and to some extent on private lands (5). Many articles have extolled the merits of this new "silvicultural system." Invariably the thesis is so simple and so conclusive that the reader who does not look below the surface is completely taken in. An early example in the Southwest is Thomson's "The Influence of Defect upon Management of Southwestern Ponderosa Pine Stands" (*10*). More recently Miles (*4*), with growth records from four small sample plots in Idaho, undertakes to prove that the only substantial contribution of increment has been made by class A trees and the younger members of class B. In a previous article (3) dealing with the same plots, the same author points to sustained annual increment averaging 135 and 145 board feet per acre during periods of 28 and 31 years, from which he argues for a cutting cycle of not less than 30 years. Miles' work is here reviewed in some detail because it illustrates well the logic and methods by which maturity selectionists have arrived at their conclusions.

Both of Miles' articles lack the descriptive data necessary to give the reader a picture of the stands. But by piecing together given information and resorting to some calculation and conjuncture it has been possible to deduce the following:

1. The stands directly after cutting were for the most part of wide spacing. This is true particularly of the Boise plots on which, with a residual volume of 3,051 board feet of pine and 133 feet of Douglas-fir, the number of pines in the 12-inch class and larger was only eight per acre. The Salmon plot with a residual volume of 5,639 board feet of pine and 1,094 feet of Douglas-fir, had 13.7 pines per acre, which is also low. Notwithstanding the small number per acre, it is still possible that the smaller trees occur in clumps.

2. Considerably more than half of the trees were blackjacks (age classes I and II) and nearly all the remainder were in age class III.

3. Advance reproduction, as indicated by a large volume of "ingrowth", must have been good at the time of cutting. Poles which have entered the 12-inch class probably have taken possession of much space in recent years.

4. Mortality has been a little more than half that usually experienced in the Southwest.

5. The classification by age-and-vigor classes was made only recently, probably at least 20 years after the cutting. Direct evidence is furnished by the columns in Table 1 giving the number of trees in each class in 1913 and 1941 on the Boise plots, and 1920 and 1941 on the Salmon plot. In both cases the number of trees in each class, after making allowance for mortality, is exactly the same now as 20 or 30 years ago. (The Salmon plot records go back to 1909). Another circumstance pointing in the same direction is that the Keen system was announced only in 1936.

6. The high proportion of class A and class B suggests that many trees were originally in lower grades and developed larger crowns after logging. In such heavy stands as the Boise plots, over 18 M per acre, it is highly probable that most of the trees left were in class C and that they advanced to class B or even A following liberation. The C trees which were not released undoubtedly remained in that class. Some of them may be former B or even A trees in advanced stages of retrogression; a few may be partially released D trees. In the light of these circumstances Miles' assurance that the C trees, as recently classified, have not been "unduly handicapped" as regards release is unconvincing.

7. Much evidence suggests that if the trees on the Idaho plots were listed individually, classifying each as to position (X, O, M, I) as well as crown size, eliminating diseased or injured trees and considering only growth 10 years before or after the classification, average growth by age-and-vigor classes would become meaningless.

8. On the Boise plots the mean annual increment of 135 board feet per acre apparently includes 52 feet contributed by in growth. In other wards, the trees 12 inches d.b.h. or larger at the time of cutting have produced only 83 board feet per acre annually, which

is not very high for site III. On the same basis, the contribution of the original trees 12 inches or larger on the Salmon plot is only 17.6 board feet* of the 145 given as the mean annual increment of the plot.

9. Periodic increment per tree in Table 3 exhibits the erratic fluctuations characteristic of small plots. But on the whole the trend is downward; even class 2A has failed to hold its own, as judged by the fact that vigorous young trees may be expected not only to maintain but to increase rapidly their periodic volume growth. Eliminating the large volume of ingrowth, even the Boise plots, on site III, have slipped badly.

Improvement of Growth by Cutting.

In the light of Arizona experience I would say that the increment of both "original" and "new" trees on the Idaho plots would be substantially higher if a second cutting had been made about 10 years ago. But much could be accomplished even at this late date. Instead of following some ready-made formula, the marker should study his stand. If he would take the plot records into the field and walk from tree to tree, he would find many exceptions to the rule that A trees grow rapidly and C trees slowly. (Growth measurements more than 10 years before or after the classification should not be used). If the marker undertakes to explain these exceptions it will be helpful to bear in mind that in the "interior" ponderosa pine type the limiting factor is not sunshine but water. If anyone doubts this, let him remember that in regions of heavy precipitation the annual per acre increment of pines, notwithstanding smaller crowns and less sunshine, is many times that of eastern Oregon, "east-side" California, or Arizona. With deficient rainfall, the only way to give a tree more moisture is to give it more soil area from which to draw that moisture, accomplished by the removal of competing trees from the root zone. Furthermore, it should not be necessary to remind foresters that increment placed on a good bole is worth many times the equivalent volume placed on a poor bole. On the whole, the great hope for better yields in both volume and quality lies in the lower diameter classes, assuming that they are present in substantial numbers as appears to be the case on the Idaho plots. The "ingrowth" class as well as the older trees needs working over with a view toward providing space for those trees whose increment will really count. The essence of silviculture is selecting the best trees and putting growth into their boles.

The bark beetle situation admittedly calls for cutting high-risk trees; but it does not justify allowing young stands to degenerate until the best stems become high-risk trees before they attain high-value production. By opening up blackjack groups as soon as natural pruning is well advanced, the remaining trees can be made to acquire all the beetle-resistance found in class A trees.

If the foregoing philosophy seems fantastic, let the reader turn back to Table 1. A tree-by-tree comparison of diameter growth in 1929-39 and 1939-44 shows a substantial acceleration in 15 of the 17 trees left by the 1939 cutting; in 8 of them the growth in 5 years after cutting nearly equals or exceeds the 10-year growth of the same stems before cutting. Since crown competition was negligible, the acceleration is attributed to increased ground space, meaning less root competition and more moisture for the trees affected. Of the five trees which grew more than 1 inch in 5 years, none is in class A, two are in class B, and three are in class C. The lesson is that growth can be increased by cutting, almost without regard for crown size above class D.

When cutting removes the trees of poorest form and quality, the gain is twofold. The 1929 volume of the entire group was 11,462 board feet. The annual 10-year increment before the second cutting was 134 board feet or 1.17 per cent; during the 5 years after cutting, which removed 43 per cent. of the volume, including the roughest stems, annual increment jumped to 175 feet or 2.42 per cent. of the 1939 volume. One 17.6 inch tree died from mistletoe and bark-beetle attack during the 10-year period, but even without this loss the increment would have been only 153 board feet. But salvage is one object of frequent cutting; at least four of the trees removed probably would not have lived another 20 years.

The group in Table I is typical of scores which would show essentially the same relationships. On the entire area of 480 acres, the net annual increment fell from a high of 115 board feet per acre 10 years after the first cutting to 52 board feet at the end of 30 years (*8*), the trend pointing toward

*Probably a small additional volume Douglas-fir.

40 feet at 35 years. But in the 30th year a second cutting removed almost one-half of the volume. During the next 5 years the increment instead of falling to 40 feet rose to 67, notwithstanding the removal of a considerable number of still vigorous mistletoe-infected trees to prevent infection of young growth. Ingrowth was negligible.

The Fort Valley experiments have taught that it is not sufficient to stand by and let trees grow or stagnate as they will. They can and should be made to grow. It also follows that in stimulating growth by silviculture, stimulation should as far as possible be applied to trees whose form promises yields of high quality. This kind of silviculture can never be attained by the unimaginative philosophy which thinks only of averages. In dealing with forest trees, as with orange trees, livestock or college students, it is the better-than average individuals that pay dividends.

Summary

Studies of growth by "age-and-vigor" classes and their application in management commonly make several fundamental errors:

1. On cutover lands a classification made now is assumed to apply at the time of cutting, perhaps 30 years ago; actually, many trees advance or decline one or more grades in "vigor" or crown size during such period.

2. Growth within each class is averaged for the whole period regardless of changes during the period, and disregarding wide variations between individual trees due to factors other than age or crown size.

3. Trees whose crowns has declined as a result of disease or injury are put in class C or D and their slow growth is used in pulling down the average of these classes.

4. The fact that a class A tree usually accupies many times as much space as a class C tree is ignored, as is also the fact that the C tree is potentially of much higher quality.

5. The possibility of improving growth and quality by cutting is overlooked. A second cutting at Fort Valley has demonstrated that well-released class C trees can be made to grow as fast as those of class A or B; clean-boled C trees which grew 1 inch or less in diameter during 10 years before cutting have grown as much or more during 5 years after release by cutting.

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THE EFFECT OF BURNING ON THE SOIL AS AFFECTING ARTIFICIAL REGENERATION*

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Introduction

Shifting cultivation is the world's simplest form of agriculture. It is practised in all tropical and sub-tropical countries wherever there are large tracts of forest, thinly peopled by primitive tribes. Each year, in due season, the shifting cultivator selects a a fresh patch of jungle for his temporary field. Here he fells most of the trees and shrubs, and spreading their brushwood and branches evenly over the plot, waits until the leaves and twigs are really dry and the day duly auspicious. He then fires his plot, and there is a mighty blaze which consumes all before it, leaving behind nothing but thick grey ashes, with here and there a smouldering log. On this clear ash-strewn ground, without any wearisome toil of ploughing or digging, he dibbles or broadcasts the seeds of his agricultural crops and in due course, with no more effort than is needed to keep his developing plants free from weeds, jungle regrowth, and wild animals, the crops ripen and the harvest is gathered.

Every cultivator is eager to secure for his year's plot an area thick with well-grown jungle.

On such sites the humus content of the soil is likely to be high, and the productivity of the temporary field, which yields so fine a crop with so little effort, is primarily due to the rich fertility of the forest soil. But there is more to it than that, for, should the misfortune of untimely rain ruin the chances of a clean burn, the wet brushwood and branches can be dragged to one side and the cleared area sown, but the resulting crops will be greatly inferior to those raised on a well burnt, ash-covered plot. When questioned, the cultivator will declare emphatically that for the best results he *must have a good burn*.

The *taungya* method of raising forest plantations is a direct adaptation of the methods of the shifting cultivator. Confronted with the task of raising a new tree crop on the site of the forest he fells, the forester enlists the assistance of the shifing cultivator, who raises the tree plants along with his own agricultural crops. In the formation of *taungya* plantations an adequate preliminary burn is as necessary for the proper early development of the forest plants as it is for the success of the cultivator's crops. Wherever suitable cultivators can be procured, and the danger from soil erosion is not too great, the *taungya* method is recognised in India as the cheapest and most efficient method of raising forest plantations. There are, however, many

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places where *taungya* methods are impracticable and there 'straight' plantations are raised without any simultaneous agricultural crop. Such plantations are usually formed on sites which were previously jungle covered, and a preliminary brushwood burn normally precedes regeneration work. The value and importance of this preliminary burn is generally recognised. The *rab* plantations of the dry fuel forests of Southern India afford an interesting example of a special method of regeneration which owes its distinctive features to the importance of a good preliminary burn. The dry type of forest in which this system is practised affords, very little brushwood on felling, and in order to get a good hot burn, all available material is collected on selected strips or patches, and there burned. In the subsequent restocking operations, all work is concentrated on the burnt *rabs*, and the intervening unburnt land is left unstocked. The "patch-sowing" method of raising *deodar* in north-west India is yet another example of a system of artificial regeneration which owes much of its efficacy to a good preliminary burn.

Thus we see that those who have to raise crops on freshly cleared forest sites--the shifting cultivator and the forester—are agreed that the brushwood burn is a very important preliminary operation. But what is the precise nature and extent of the effects of burning on the fertility of the soil? Are they due to the burn or the ash or to a combination of both? How do these effects vary with different crops and with different local conditions of soil and climate? What is the most economical method of obtaining the maximum benefit? The answers to these questions can only be given by objective experiments, carefully conceived and as carefully executed.

The scientific study of the soil is a very new science. For untold centuries man has applied himself to the cultivation of agricultural crops, and by empirical methods he has accumulated a mass of valuable experience. Formerly he was often unable to correlate cause and effect with proper precision, and it is only in recent years that efforts have been made to elucidate something of the complex subject of soil fertility by scientifically designed experiments. Naturally enough, the first efforts of the modern school of soil scientists have been mainly directed towards a solution of the many important fertility problems which concern permanent agricultural lands. Problems of the fertility of forest soils, and of lands which are used for only temporary cultivation have so far received little attention.

In the past we have received many enquiries for information on particular aspects of this problem. To answer each of these enquiries usually involved a long search through a very wide range of literature because the subject is one that has been little studied directly and most of the relevant information has been recorded in work on various subjects which have a bearing on the problem.

As a result it was decided that a comprehensive search through the literature followed by a brief write up summarising and listing the publications would help to concentrate work on the subject. This was done early during the war but the bulletin was not published owing to the paper shortage then existing. It has new been sent to the press and we hope it will have appeared before the conference*. It is realised that there are many gaps which remain to be filled but it is hoped that this publication will cause those interested to help to eliminate these depressions in a future publication.

The soil complex

A mature fertile soil is a highly complex system. The bulk of the soil consists of mineral matter resulting from physical and chemical weathering of rocks and organic matter (or humus) derived from decaying plants and animals. The mineral part consists mainly of sand, silt and clay. The sand and silt are generally speaking the products of physical weathering of rock and retain the original properties of the rock minerals, while the clay is a result of chemical weathering in which the properties of the original rock are changed considerably. The clay and the organic humus together are called the soil colloids and it is these which give the soil such specific properties as base exchange, swelling, crumb formation, moisture retention, acidity, etc., which differentiate it from a mere physically disintegrated rock consisting of sand and silt. Non-colloidal sand and silt however play their part in modifying the textural properties of

*GRIFFITH, A. L. 1943 (published 1946). The effects of burning on the soil as a preliminary to artificial regeneration. *Indian For. Bull.* (n. s.) *Silviculture* No. 130.

the soil. The colloids partly coagulate into crumbs and partly cement together the sand and silt thus creating an internal surface within the soil mass with pores of different sizes. This pore space is occupied partly by air and partly by water, or more correctly speaking, soil solutions, for it carries in solution and suspension a variety of products of decomposition of mineral and organic matter.

Throughout this solid, liquid and gaseous mass there thrives a teeming community of living organisms, protozoa, bacteria, fungi, insects and other animal and plant life. The whole elaborate system is best considered as a living entity—the SOIL COMPLEX—a complicated and delicately poised community dependent for its stability on a number of internal and external factors. The combined interaction of all the chemical, physical and biological elements of the soil complex, together with the influence of the external site factors are reflected in soil fertility. Alterations to any of the controlling factors may change the whole balance of the complex, and thereby alter profoundly the fertility of the soil.

The effect of the fire on the soil

The burning of stacked debris on a regeneration plot will influence the soil complex by two principal means. Firstly, there is the heat of the fire an influence which is violently active only during the actual duration of the burn though the effects on the soil may be profound and last for a considerable time. Secondly, there is the influence of the ash left lying on the ground after the burn. The effects on the soil resulting from this influence will be more gradual though they may ultimately be as important as those attributable to the influence of the heat.

Theoretically these two influences—the burn and the ash—will operate quite independently in affecting the equilibrium of the soil complex.

Generally speaking, however, one would expect the heat and the ash to affect the soil as follows :—

Burning :

(*a*) Burning removes the surface organic matter which is normally the exclusive source of supply of nitrogen to the soil. In conseqence even though mineral salts such as phosphates and oxides of alkalies and alkaline earth are returned to the soil as ash the future supply of nitrogen is almost completely lost, at least temporarily.

(*b*) The heat of the burn, if it is intense, breaks up the colloidal clay complex leaving an ignited inert material devoid of such properties as retention of nutrients, moisture, etc. This will of course depend on how deeply the intense heat penetrates.

(*c*) Colloidal gels are likely to be dehydrated and shrivelled up, thus giving the soil (and particularly a clayey soil) an open texture. This will obviously benefit the plant in a clayey soil.

(*d*) Heat will affect the micro fauna and micro flora of the soil thus upsetting the biological balance. One important effect is that protozoa are killed and in their absence the nitrifying bacteria (on which the protozoa feed) flourish and thus create an increased amount of nitrates in the soil.

Ash :

(*a*) It will obviously be a source of mineral nutrients such as potassium, calcium and phosphates.

(*b*) Highly alkaline ash, when leached into the soil, may however be detrimental (especially if the soil is clayey) because alkalies will defloculate the clay. The clay will thus enter the pore spaces resulting in the following effects :—

I. Soil stiffened by decreased pore spaces will have an increased surface run off and will thus be more susceptible to erosion.

II. The infiltration of water will decrease and thus will lead to a dessication of the soil.

III. There is a decrease of soil aeration which will be detrimental both to plant roots and the micro biological population of the soil.

IV. Alkaline ashes will neutralize the acidity of the soil which may be helpful to bacterial activity.

The bulletin goes on to consider the information in existing literature of the effect of the burn and the ash separately in causing chemical, physical and biological changes. This is too lengthy and too complicated to be summarised in a paper of this sort and for details the original bulletin should be consulted.

The Dehra Dun experiments

Very little experimental work has been done on this effect of a burn before regeneration in India or in tropical countries. Most of the work has been done on the soil itself and often it has been confined to laboratory work.

In view of the paucity of reliable information in this very important problem particularly with regard to tropical conditions it was decided to carry out some experiments at Dehra Dun. These experiments were intended to be exploratory and from the beginning it was realised that the soil in the forest research institute estate is not a forest soil as was to be desired for the experiments but an exhausted agricultural soil. The advantages of doing the experiments where they could be continually observed outweighed this disadvantage. The main intention of the experiments was to find a technique by which the problem could be tackled and to endeavour to realize the snags likely to occur.

In consequence an experiment was started in 1938 in the experimental garden of the forest research institute to try and elucidate the relative effects of burning itself as distinct from the ash from a study of four different treatments. This first year's experiment quickly demonstrated some of its faults and it consequently led to further work with a more elaborate lay out in the following year.

The final experiment consisted of 16 replications of 4 treatments with 10 species, the treatments being (A) clear felling and burning the slash, the ash to be worked into the soil, (B) clear felling and burning the slash, the ash to be removed from the area, (C) clear felling and removing the slash from the area ash from (B) above being worked into the soil, and (D) clear felling and removing the slash from the area (control). Results were assessed on height growth at the end of the first and second growing seasons. Soil samples were taken before the experiment started and two months after the burn after the first light shower of rain.

The following conclusions were drawn from the experiments :—

Soil values.

I. Removal of ash from a burnt area causes a significant decrease in the moisture equivalent.

II. Burning and more especially the ash causes a significant increase in the pH units in the top soil tending to make the soil more alkaline.

III. Burning and more especially the ash causes a significant increase of nitrogen as nitrates.

IV. The heat of the burn penetrates so slightly into the soil that even in the top 3 inches it is not intense enough either to destroy the intimate humus or to break the clay complex.

Effect on height growth.

V. Burning with or without removal of ash causes a significant increase in height growth but the intensity of the effect varies with the different species.

VI. The addition of ash to an unburnt soil causes a significant increase in height growth but this increase is much less in intensity than that caused by a burn with or without the removal of the ash.

VII. The beneficial effect on the height growth is much more pronounced in the first year than in the second year but even after two years the differences are still significant.

It must, however, be remembered that these conclusions have been reached as a result of experiments carried out on a loamy exhausted agricultural soil and not on a forest soil. The experiments were primarily intended to explore a technique for the work and not to produce definite end results on the problem itself.

Experimental evidence from the provinces

The effect of burning on the growth of the subsequent regeneration has generally been accepted and taken for granted. The practice of burning before artificial regeneration is largely confined to the moist deciduous and semi-evergreen types of forest. In these types usually the actual regeneration is easy and the burn although not an essential is largely used to clear away the felling debris and to discourage early weed growth. It is in this type in particular that the effect of the burn has been

taken for granted. It is in the types such as the dry fuel forests and the evergreen forests where regeneration is not easy that the effect of the burn has been studied seriously.

The small amount of work that has been carried out is discussed below according to the forest type in which it was done.

Dry fuel forest type (annual rainfall about 25 inches).

Fairly extensive work has been done in this type in Madras. The following figures give the results on survival percentage and mean height growth after 1 and 2 years of 29 experiments done with 10 species by direct sowing over a period of 5 years from 1934 to 1938. There were four treatments :—(A) soil worked but not burned, (B) soil neither worked nor burned, (C) soil burned and worked and (D) soil burned but not worked.

Measurements at the end of the 1st and 2nd growing seasons after planting.

	Survival percentage.				*Mean height growth in inches.*			
	No burn.		Burn.		No burn.		Burn.	
	Worked pits.	No soil working.	Worked pits.	No soil working.	Worked pits.	No soil working.	Worked pits.	No soil working.
At end of 1st growing season.	48	43	62	58	3.4	3.3	6.9	6.2
At end of 2nd growing season.	16	14	49	47	12.3	10.1	22.9	19.7

The species used were *Acacia arabica, Acacia leucophloea, Acacia planifrons, Albizzia amara, Cassia auriculata, Cassia siamea, Dolichandrone crispa, Tamarindus indica, Wrightia tinctoria* and *Zizyphus jujuba.*

These results can be grouped into burning and non-burning, and soil working and non-soil working as follows :—

	First year.		*Second year.*	
	Survival percentage.	Mean height growth in inches.	Survival percentage.	Mean height growth in inches.
Burning ..	60	6.6	48	21.3
No burning ..	47	3.4	15	11.2
Worked pits ..	55	5.2	33	17.6
No soil working ..	51	4.8	31	14.9

The above table thus shows that burning had a very great effect on survival percentage and mean height growth. It also shows that the ash had an appreciable effect but this effect was much smaller than that due to the burn.

We thus get the conclusion that in dry fuel forests burning before sowing is essential and that soil working before sowing and thus working the ash into the soil is decidedly beneficial.

Further work in Madras has also tentatively shown that the interval that elapses between the burn and the sowing of the seed has an effect on the results obtained. The experiments so far indicate that burning one to two months before sowing gives the best results.

Moist mixed deciduous forest type—(annual rainfall about 100 inches). Only one experiment appears to have been done in India in this type and that was at Nilambur in 1930 in a second rotation teak plantation. Four treatments were used (A) control, (B) unburnt, ash added, (C) burnt, ash removed, (D) burnt, ash retained. Measurements in June 1931 showed that the mean height growth in inches was (A) 20, (B) 28, (C) 40, (D) 42.

The experiment thus showed the great effect produced by the burn. The addition of ash to the unburned plots produced an appreciable but smaller beneficial effect.

A fairly comprehensive experiment was done in Java by COSTER. An area containing a 17-year old crop of *Leucaena glauca* was felled and in 4 blocks the debris was spread evenly over the area and burned, while in 4 other blocks it was removed and the old stumps were dug up. Teak was raised on the area in conjunction with crops of rice and maize. In the burned areas the rice and maize crops were 40% greater than in the unburned areas.

In the first year the height growth of the teak in the burned plots was 62% better than in the unburned plots, while in the second year the superiority was still 33% in height growth and 23% in diameter growth. COSTER concluded that the cause of the difference was the manuring value of the ash. Roughly 43½ tons of dry *Leucaena* matter were burned per acre which gave a manure of ¼ ton of ash with a high percentage of potassium and phosphorus compounds.

Large-scale evidence of the effect of the burn is mainly confined to teak plantation areas. At Nilambur (Madras) the failure of some of the early second rotation plantations was attributed to the poorness of the burn (though it was later found out that this was not the primary cause). This was due to the lack of material available because in natural forest comparatively little of the produce is saleable while in a teak plantation practically all the produce is saleable. Therefore in second rotation regeneration as much material as possible should be retained for the burn or if close utilisation is carried out it must be remembered that intensive weeding must be done to make up for the paucity of the burn.

In general teak plantation work in the wetter areas where conditions approach evergreen, the opinion is held that a burn is essential and that the heavier the burn the better is the resultlng plantation. The burn is necessary to remove debris and to reduce the subsequent growth of weeds, climbers, bamboos, and evergreens. In moist mixed deciduous types it is held that the burn is beneficial but not essential if we are prepared to carry out intensive and expensive weeding to replace it. In these types also the opinion is generally held that care must be taken not to have too intense a burn. Such over-burning bakes and cakes the soil and temporarily renders it unfit for or deleterious to the growth of teak. Local over-burning by the quantity of ash it produces also results in a similar effect.

In recent tours a number of examples of slow early growth have been seen which were due to over burning in an attempt to reduce weeding costs. The danger of too fierce a burn is even greater in the drier types.

If the burn fails or partially fails extra care and expenditure must be spent in piling and reburning and for this to be successful billeting is often necessary as the initial burn has usually removed all the small branchwood and brushwood. Even if the reburning is fairly successful, intensive subsequent weeding is an essential to overcome the results of the failure of the initial burn. It may even be necessary to postpone the planting for a year as occasionally happens in Burma.

Tropical wet evergreen forests (annual rainfall 150 to 250 inches). A series of eperiments were done in the Madras overgreens to determine the effect of a burn before artificial regeneration. Twenty-four experiments were done over a period of 5 years from 1932 to 1937. The burn produced no significant difference in either survival percentage or in mean height growth as measured at the end of the first and second growing seasons after planting, thus indicating that the burn if not actively harmful in no way benefits seedling growth in these forests.

The species used were *Artocarpus hirsuta, Calophyllum elatum, Cedrela toona, Dipterocarpus indicus, Dysoxylum malabaricum, Hopea parviflora, Mesua ferrea, Swietenia macrophylla* and *Gluta travancorica*.

It must however be remebered that conditions in evergreen forest are very different from those of the dry fuel and moist deciduous types already referred to. The artificial regeneration is done under top canopy shade and only the middle and under storeys are felled. Further, the forest is characterised by a very shallow soil, surface rooted species and a very quick turn over of leaf-fall, leaf litter, decomposition and return to the soil of nutrients, followed by quick assimilation by the surface roots.

These experiments also demonstrated a disadvantage due to the burning in that the

top canopy trees which are needed for shade for the subsequent artificial regeneration are susceptible to fire and three times in three years it was found that areas had to be abandoned after the burn as the fire had killed some 40 per cent of the trees intended to be left as top canopy shade.

Literature

The bulletin lists 50 publications which were consulted. It is a very wide literature but as already noted most of the publications only bear indirectly on our problem.

Conclusions

In a short paper like this for the conference it is only possible to touch on the salient points of the problem. The bulletin referred to is itself very condensed and is almost impossible to summarise adequately.

It must also be remembered that the particular aspect of soil fertility which we are considering has received very scant attention from scientists in the past and that theoretical conjectures are far more plentiful than scientifically established facts.

It is hoped however that this paper demonstrates how incomplete both our practical and our theoretical knowledge is of the details of this most important problem, and that the conference by its discussion and the resolution it finally adopts will indicate the lines on which it considers further work can be most usefully conducted.

USE OF MINOR FOREST PRODUCTS IN BURMA DURING THE JAPANESE OCCUPATION

By M. V. Edwards.

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The Japanese occupation of Burma for three years entirely upset the internal economy of the country, with the result that some interesting substitute materials were brought into use. Little petrol and kerosene (paraffin) were available to the ordinary civilian, the Japanese using what was obtainable from the devastated oilfields for their military purposes, and so substitutes obtained from local products were used. Burma was not a great producer of textiles, in peace-time, and though before the war the Japanese poured large quantities of textile fabrics into the country at cheap rates, once they had conquered the country for themselves, they failed to provide sufficient imports of material to clothe the people. Fibre to replace the jute, coir and hemp formerly imported also had to be developed.

These notes were collected during the advance of the Fourteenth Army through Burma and in Toungoo district while the reoccupation was being completed, while the substitutes were still in use. They are probably now no longer used.

Petrol

The Japanese 'co-prosperity sphere' was not short of rubber and in Burma they only took over the estates of certain European rubber planters, leaving the Burmese estate owners almost without a market for their rubber. Apparently on their own initiative and without Japanese aid, they developed a motor spirit from distilled rubber, which, if a poor substitute for petrol, at least kept the Burmese-owned motor bus plying on the road. When this was developed full tapping of rubber estates was resumed, and they were even tapped all the year round. The lack of formic and acetic acids for coagulation was satisfied by using fermented rice bran, which apparently proved entirely successful except for difficulty in filtering away some specks of bran which remained in the rubber sheet.

In Shwegyin, Toungoo district, distillation of rubber started about the cold season of 1943-44, and towards the end of the Japanese occupation anyone who could manage to obtain a 44-gallon drum set up a still, and hundreds were said to be in operation. The still consisted of a drum with the top cut out, set upright on a brick fireplace. The top of the drum was closed with a shallow iron pan (*de-oh*) filled with water and sometimes weighted down with laterite blocks. From the upper part of the side of the drum ran a straight piece of one-inch or two-inch iron pipe (some-

times bamboo was used) twenty feet long. It rested in a wooden trough full of sand packed round the pipe and kept wet. This pipe led to another coiled pipe immersed in another drum of cold water, and the distillate was collected as it ran from the end of the coil.

This still was copied from those used for distilling country spirit made from the juice of the toddy palm. In the latter type of still the spirit condenses from the under-side of the pan used as a lid and drops into a funnel inside the still leading to the condenser pipe, thus the still and lid really act as a combined still and condenser. This system did not work with rubber, and the function of the water in the lid seems to have been merely as a weight to keep the lid tight.

The water was allowed to get hot. Mud and dung were also used to seal the joint. Some distillers gave up this type of lid and used a metal plate bolted on, but this took too much time to open and close.

In this still rubber sheet, was placed, usually whole, but, by some, cut into small pieces. A still took a charge of about 120 lbs. sheet and distillation took about 6 to 8 hours. Two charges could be run in a day.

The first fractions of distillate contained water and were not suitable for motor spirit. They were collected and often placed in the next charge for redistillation, though it was considered that this could only be done 5 or 7 times and that then a dry charge must be run.

All the rest of the distillate was sold as motor fuel, though it was said that there was some water in the last fraction distilling over and also left in the still, which hardly seems possible. Perhaps it was a clear oil of higher boiling point. The thick oil left in the still was mixed with a proportion of the spirit and sold as engine lubricating oil, or if very thick as gear oil!

The outturn of spirit was quoted as from 9 gallons to $10\frac{1}{2}$ gallons per charge of 120 lbs. of rubber. The price was Rs. 35 (Japanese currency) per 4-gallon tin at the start, but it rose continually as the value of money depreciated. There was a very large demand, larger than could be met, and rubber was even imported from Thaton, Tenasserim, for distillation.

The spirit turned red on standing and after about 7 days deteriorated in quality, so that it was necessary to use it quickly. Owing to the large demand this was apparently easy.

In the Shan States where *Pinus khasya* and *P. merkusii* are found, it has been reported that 'Experiments by certain chiefs to obtain turpentine as a motor spirit led to extensive tapping of pine in Kalaw, Mong Nai, Mawkmai, Lai Kha, Mong Kung and in Karenni. The methods used in tapping and distillation were crude. Tapping was done by making an incision at an angle of 45 degrees to the axis of the tree 4 ins. to 5 ins. deep and 1 foot to 2 feet long, according to the girth of the tree, and catching the resin that exuded in a cup or tin. The cut was never freshened and when it ceased to yield a fresh cut was made. Sometimes the cut was V-shaped. The method imposes a severe strain on the vitality of the trees tapped and might kill a number of them. The forest ranger stated that the work was confined to the immediate neighbourhood of villages and he estimated that not more than 2 per cent. of the total stock was damaged. The apparatus for distillation was an adaptation of that used for country liquor. The turpentine was used locally in cars and lorries, and the rosin was sent to Rangoon for the caulking of boats.' (F. Allsop.).

Kerosene

The shortage of kerosene immediately led to a revival of the use of wood oil from various species of *Dipterocarpus*, *Kanyin*, well known as an illuminant in the days of the Burmese Kings. This was collected by the usual old-fashioned method of tapping by making a hole in the tree near its base, combining both tapping surface and cup. Resin production was often stimulated by fire. The production has been estimated at 15 viss (one viss equals about $3\frac{1}{2}$ lbs.) or about 50 lbs. per tree per year over the usual dry season tapping period of a few months. (A. Rodger, *Handbook of the Forest Products of Burma*, 1943 edition, page 86). A limit to production of 100 viss per 25 trees per month was fixed, and if it is assumed that the tapping period is $3\frac{3}{4}$ months per year, this is equal to 50 lbs. per tree per-year. A tapping period of $3\frac{3}{4}$ months per year is reasonable, and it was said that small scale tests in North Toungoo division showed that 100 viss per 25 trees per month was a reasonable actual yield. Probably a yield of

this size would seriously impair the vitality of the tree, and if tapping was carrid on for more than three or four months in a year, would soon cause it to die. But with the use of these large tapping holes and fire, death of the tree is almost inevitable in any case, and limiting the yield is not likely to be of much help.

The crude oil can be used in a hollow bamboo as a naked light but the bamboo tends to crack and then the whole stick burns. It was more frequently mixed with rotten wood (*thitswe*) or sawdust and made into a torch consisting of a tube of *salu* (*Licuala peltata*) or other palm leaves tightly packed with the mixture. Four gallons of oil mixed with rotten wood make one *kanyin baing* and one *baing* makes 16 torches. If more than 16 are made from this quantity of oil, the quality falls. The crude oil was also used to light fires, ten to twenty drops of oil being sprinkled on the wood before kindling.

To make a better kind of oil, the crude oleo-resin was also distilled by the villagers in the same kind of apparatus as has been referred to above for rubber. The best crude oil yields 40 per cent. first quality distillate, 10 per cent. second quality and 10 per cent. residue, 40 per cent. being lost in distillation. The first quality oil was used for lamps, and one gallon of the same quality oil mixed with 3 gallons of residue was used as cart grease (*hlesi*). The residue hardens to a substance like *indwe* (resin from *Dipterocarpus tuberculatus*, a dipterocarp which produces an oleo-resin much more solid than wood oil) when cold, and when about 5 tinsful (20 gallons) had been collected, they were mixed with 5 gallons of water, 5 gallons of second quality distillate and boiled for 3 or 4 hours until no water was left. This preparation was known as vegetable tar and was sold to Japanese firms who used it for caulking and varnishing boats, and for painting wood and bamboo work. Experiments were made with it as a road tar, mixed with small size broken road metal, but when used for patching the whole mass of tar and stone did not hold firm but was lifted off by traffic. It was also used like a candle in a hollow bamboo, but the stick tended to get hot and the oil flowed away.

Tapping of the trees was controlled by the forest department, a license for 25 trees of breast height girth of 8 feet and above being issued to each tapper. A limit on production of 100 viss per 25 trees per month was fixed. Two tapping holes were permitted on trees 8 feet to 12 feet in girth and three holes on larger trees. The depth of the hole was limited to 9 inches and it had to be between 3 feet and 4 feet 6 inches from the ground level. The trees had to be protected from fire during the hot season between—February 15th and May 31st by sweeping the ground to a distance of three feet round each tree.

When distilling the oil, various chemicals were introduced in an attempt to reduce its smokiness. Each distiller probably had his own formula, the two following were typical :—

	(*a*)	(*b*)
Crude oil, 4 tinsful	16 gallons	16 gallons
Lime	2 ticals	10 ticals
Salt	2 ,,	12½ ,,
Soap	1 ,,	
Alum	1/10th ,,	½ ,,
Ammonia	1/10th ,,	½ ,,
Red arsenic	1/10th ,,	
Sulphur	1/10th ,,	
Saltpeter	1/10th ,,	

The effect of these additions is doubtful, and it seems more than likely that they represent a list of all the chemicals available in the local *bazaar* and all were used on the hit or miss principle. Experiments were performed with improved distillation methods and double distillation produced an oil which was said to be useful also for motor spirit. This oil in ordinary hurricane lamps gives a poor smoky light, better than nothing, but not comparable with kerosene. For motor spirit it was mainly used as a diluent of black-market petrol which could be sold for very high prices.

Fibres

No satisfactory substitute textile fibre was produced, though the outturn of cotton in the dry Zone was increased, even under Japanese pressure at the expense of food crops. Many of the Burmese women made their blouses or *eingyi* of a green fabric apparently used by the Japanese as mosquito netting. By some this was said to have been made from some form of *Sterculia* fibre (*shaw*), but by others it was said to have been imported from the Philippines, and this is more probable.

For sewing cotton the fibres from pineapple and agave leaves were very commonly used, and seem to have been the mainstay of the villagers for repairing clothes. This is known as *nanat shaw* and it was made as follows :—

A leaf, which is about 1 inch wide and 20 to 30 inches long is rubbed on the upper surface with the edge of a plate or bowl until all the soft matter is rubbed away and the fibres are exposed. They are then scraped with a pin and raised off the rest of the leaf thereby. They can then be pulled away from the leaf quite easily. A bundle of fibres to make a thread of the required size is rubbed with grains of cooked rice and the bundle is then twisted between the palm of the hand and the knee, one end of the bundle being kept fixed. After rubbing and smoothing the thread is ready. Very strong and even threads up to two cubits (3 feet) in length can be made in this way, they are easy to sew with and durable.

The Japanese made large demands on forest and other indigenous fibres for making string and rope in place of coir and jute. They appointed agents and collecting places all over the country for all kinds of *shaw*. *Shaw* is mainly the phloem or bast fibre of species of *Sterculia*, but probably fibres from other species such as *bambwe* (*Careya arborea*) were included. These were stripped from the green trees as soon as felled, and very large numbers of trees were thus felled and left lying to rot.

The cultivation of *paiksan shaw* (its origin is not traceable yet) was encouraged and considerable quantities were grown around Kama in Thayetmyo and exported to Rangoon. In the Sittang valley it was also planted, but the soils on which it was most successful were apparently the fresh alluvial land beside rivers and these were suitable for tobacco which was a more paying crop. However under pressure a good deal was grown. The plant, which is somewhat like sunn hemp or jute, was sown about October or November, after the rains, and matured in in about three months, when the plant was about five feet high. The seed of the Sittang valley plant has been sown at the Forest Research Institute, Dehra Dun, and identified as *Crotolaria Juncea* Lipn. After reaping the stems were soaked in running water for 5 to 6 days and then after shaking in the water the fibres could be easily and cleanly separated. Some said that the fibres needed to be hammered in this rotting process. They were then spun into string and rope. This rope is said to be very inferior to the rope made in Burma before the war from imported coir, but the inferiority seems to be mainly in being less waterproof as the strength is apparently good.

Roselle fibre from species of *Hibiscus* was also used, but apparently only on a very small scale. *Katsihnin* fibre, which is made from species of *Urena* and *Sida* was said to be commonly used in the Sittang valley.

The Japanese seem to have shown most interest in the *shaw* from *Sterculia* which is commonly used in making bamboo huts as well as to make strong rope, and in the *paiksan shaw* which they had made into rope and stored near Rangoon in large quantities. Its purpose is not known, for much of it was destroyed by—bombing and the remainder was left behind unused at the time of their hurried departure.

AFFORESTATION ON THE KANKURA HILLS OF AURANGABAD FOREST DIVISION

(H.E.H. the Nizam's Dominions)

BY SHARFUDDIN KHAN (DIVISIONAL FOREST OFFICER, AURANGABAD).

Aurangabad is the most important and historically interesting city of Hyderabad State, enclosed by hills and hillocks which rise from a few hundred to 1,000 ft. above the surrounding country attaining at times 3,000 ft. above mean-sea-level. In these hills are situated the famous Ajanta and Ellora caves which are centres of attraction for art lovers. Here Nature smiles in emulation of the work of the pastmasters of the chisel and easel.

Situated on the north-western extremity of the state, this division enjoys a temperate climate. The average rainfall is 28 inches and the shade temperature varies from 42°F in the cold weather to 110°F in the hot season. Hot winds in summer promote the danger of forest fires in areas which abound in grass (and such areas form about one-third of the total forest area): water is scarce in the hot season.

The area of the forest is 344 sq. miles or 4.22 per cent. of the total district area. This area is generally situated on the slopes of meandering hill ranges, having spacious terraces on the top which are occupied by cultivation. The slopes are steep and often difficult to climb. The entire rock system is Deccan-trap. The soil is rich black cotton soil changing to light loam and ferragenous clay. The slopes have practically no soil on them and not infrequently the surface has reached the last stage of erosion. The plateau however, contain good black cotton soil, though of uncertain depth, very suitable for field crops, but not so for the tree growth. The soil cracks under the influence of heat and cold, which render it unsuitable for the regeneration of young forest trees.

These hills were covered with rich forest growth of deciduous species in which teak was found in varying percentage according to the soil conditions, but, due to ruthless eradication of most of the forest areas for the extension of cultivation, only eroded hills and hill slopes were left. These areas were ultimately taken by the Forest department and were demarcated as reserved forests. But forestry being in its infancy in those times in Hyderabad State and the department being in non-technical hands, revenue was considered of far more importance than the technique of improving, preserving and propagating forests. The result was, that due to over exploitation, adopting the simple coppice method of working, constant fires and over-grazing, the once beautiful forests which induced the spiritual artists to immortalise their works in these hills disappeared, giving way to thorny bushy species. Erosion has set in and sheet rock has appeared here and there.

Destruction is easier than construction. It took us 80 years to bring the forests to the present ruined state and how long will it take us to put them back to the normal condition, is easy to imagine. This can only be achieved by large scale afforestation. Afforestation works were started in this division in 1943. The methods adopted were :—

(*a*) Contour trenching and after filling in the soil in the trenches slantwise at an inclination of $\frac{1}{3}$ to form seed beds, seeds of hardy species such as *Acacia arabica*, *Melia indica*, *Bauhinia racemosa*, *Zizyphus jujuba*, *Semicarpus anacaedium*, *Anona squamosa* and *Boswellia serrata* were sown on the hill slopes.

(*b*) The agri-cum-silvicultural method (taungya) was adopted on the plateau and on the plain country and ;

(*c*) Areas were rigidly closed to felling, grazing and fire damage.

The results obtained in the first two years of the operations were very discouraging owing to the following facts :—

(*i*) The staff was quite new to the work and timely directions were not carried out properly.

(*ii*) Unsuitable species such as teak *Tamerindus indica*, *Dalbergia sissoo* and *Anogeissus latifolia* were sown which germinated profusely but did not withstand the drought between the long spells of the monsoons.

(*iii*) The trenches dug along the slopes of the hills were not exactly contour-wise and were too near each other so that the rush of water had broken these trenches and swept away the seeds.

(*iv*) In agri-cum-silvicultural operations, timely sowing was not adhered to.

(*v*) Cultivators were more after their crops than taking care of forest lines.

The best and astonishing result that has been achieved on the hills is their complete rest and strict closure to grazing and complete fire protection. Nature has established herself wherever factors turned favourable.

The writer's experience of afforesting steep hilly slopes which are heavily eroded is that complete closure from grazing and fire protection is necessary and trying to dig trenches and sow seeds here is merely waste of time and money.

The above note is little more than a record of failures, but as in forestry a record of failures is as interesting as that of success, it is hoped that this note will be found interesting to readers.

CONTOUR BUNDING AND TRENCHING AS COUNTER EROSION MEASURES ON THE NILGIRIS *

By P. W. Davis

(*Soil Conservation Division, Nilgiris, Madras*).

This type of counter-erosion work. is so far in a very primitive stage being limited to a few pyrethrum plantations on the Nilgiris where works were hastily constructed in 1943 at a cost of Rs. 10/- per acre and subsequently maintained with desultory improvements here and there at a cost of Rs. 26-4-0 per acre in 1944. But nowhere have they been constructed thoroughly scientifically or with true experimental purpose in view. In 1941 the Soil Erosion sub-committee of the Nilgiris district Periodical Council laid out a series of experimental contour drains in a privately owned cultivation of about 8 acres extent, at a cost of Rs. 26/- per acre (including the construction main drains) but lack of funds prevented subsequent maintenance. They were adequate to arrest soil losses for a period of two years but left to the owners they badly deteriorated by neglect and ceased to be effective thereafter.

The plateau region of the Nilgiris was initially gently-rolling pasture and woodland, receiving an annual rainfall of 45 to 80 inches according to locality but liable to downfalls of 4 to 5 inches intensity in 24 hours (occasionally up to 7 inches). The natural vegetation was adequate to ensure a gentle distributed run off from the slopes with the result that the stream and torrent beds are often surprisingly few. But after the vegetation is cleared for cultivation severe sheet erosion rapidly sets in with losses from 100 to 500 tons per acre per annum. With the disappearance of the top soil a thin gravelly layer is disclosed below which is a red or pink mineral subsoil of clay and coarse sand of an extremely erodible nature. Drainage channels, fences, cattle tracks, etc., near the gravelly layer are liable to cause a scouring into the lower erodible layer resulting in rapid and deep gullying. An initial difficulty in such country therefore is to arrange the safe conduct of impounded water by artificial channels into natural stream beds which are often at some distance. This however is a local problem to be overcome whatever the form of terracing adopted.

Prima facie, counter drains with low-gently sloping *bunds* constructed wherever possible on the upper side of the drains are a type of work which should be effective on the more moderate cultivated slopes up to a gradient of 1 in 6. Beyond that gradient their effectiveness appears doubtful. The prevailing cultivation of potatoes in the Nilgiris requires effective drainage, and stagnation of water is to be avoided. The *ryot* (cultivator) employs a herring-bone system of drains which while it gets rid of surplus water saves no soil as the drains are never on a contour. Strict contour levelling of drains was not possible even by departmental effort in the pyrethrum areas as forking of the turf had to be done in a great hurry and in advance of trench construction so that minor differences of level were apparent. Subsequent lock-and-spill devices were imperfectly attempted with only partial success, and could have been done better. Again, the susceptibility of pyrethrum to water logging caused the staff greater preoccupation than maximum soil conservation, and gradients of 1 in 100 and 1 in 200 were generally pegged out, which caused a rate of flow sufficient to carry off most of the finer soil. The heavy weed growth on intervening strips was cast on the *bunds* which did save much soil, but inevitable weak spots occurred where water poured over and across the flooded drains causing ril gullies down the slopes. Weeds are now uprooted and more usefully employed as a mulch on the strips.

It is very apparent that any drainage system to be effective requires not only the most meticulous alignment and careful design in the first instance but must be constantly attended to and the deposited silt in the drains must be removed at frequent intervals. Left to the initiative of private owners without

*Paper read at the 7th All India Silvicultural Conference (1946), Dehra Dun, on item 4—Contour bunding and terracing as counter erosion measures.

supervision the system will inevitably fail. It is necessary to provide that the system when once constructed shall be maintained by the owners at their cost, and this entails supervision by the authorities. Ordinary revenue officials will be unable to attend to this work, and it follows that a special maintenance staff will have to be employed.

AUSTRALIA'S TREE SPREADS OVER THE WORLD

By Jack Bowen

Australia's eucalypts are possibly the world's greatest tree migrants. Their leaf shadows fleck the soil of Italy, Spain, France, the Americas, New Zealand, the Pacific Islands, Africa, India, and even the south of England.

The eucalypts' latest migration is to Georgia Soviet Russia, where 40,000,000 of these evergreens will be planted in a vast re-afforestation scheme. In California, they are so many that Californians sometimes stoutly claim them as their own.

First among Australian trees, the eucalypt is unique, and truly native to Australia. The genus forms about 90 per cent. of Australia's standing commercial timber, and contains most of the really tall trees of Australia.

If you exclude the low-standing members of the legume family, such as the wattles, nine out of every 10 trees in Australia are eucalypts. There are, possibly, about 1,000 species in the genus—of which about 500 have been classified.

If you mention eucalypts to the average Australian, more likely than not he will say, 'Ah, yes, gum trees." But gum trees, although the most conspicuous of the genus, number only 120 species out of 500 odd that have been classified.

The first settlers in Australia saw some eucalypts with smooth trunks which periodically shed their bark and exuded kino, a form of gum. These they called "gum trees." a very loose term which could as aptly have been applied to any tree that exuded gum.

To the other eucalypts, which retain their bark, the settlers applied a variety of names, more or less descriptive, but not always exact, such as peppermint, mahogany, ironbark, stringybark, messmate, box, oak, spearwood, tallow-wood, bloodwood, ash, woolybutt, blackbutt, leather jacket, apple and so on.

These names were given sometimes because of the timber or the bark, and sometimes because of the smell of the leaves. These popular names cause confusion today among foresters, timber users, and the general public alike. The term, "blue gum", for example, is applied to at least eight different species of eucalypts, "red" to 10, and "white" to 15. One eucalypt is known in various parts of Australia as peppermint, mountain ash, giant gum, white gum, stringy-bark, manna gum and messmate. Significantly, it is only in Western Australia—the one Australian state ettled mainly by Australians and not by exiled Europeans—that there has been any determined attempt to follow the clearly better system of retaining aboriginal names for eucalypts. There, aboriginal words such as *jarrah* for *E. marginata*, *karri* (*E. diversicolor*), *wandoo* (*E. redunca*) and *tuart* (*E. gomphocephala*) have been kept alive.

The genus eucalyptus was first named in 1788 by l'Heretier. To a specimen of what is now known to botanists as Eucalyptus obliqua, collected from Tasmania by Nelson and Anderson on Cook's third expedition in 1777, l'Heretier gave the very apt name of eucalyptus (eu=well ; kalypto=I cover.) This was a description of the lid or operculum which covers the stamens so effectively in the bud stage.

Giant Trees

Just where the eucalypt originated is uncertain. It possibly had its birthplace to the north-west of Australia, and passed down the Western portion of Australia sometime before the land mass of Australia was separated from the Asian mainland.

Most of the Australian eucalypts (like other commercial timbers of the Australian continent) are hardwoods. Australia has few softwoods.

Australian hardwoods were exported from this country long before we were exporting wheat, wool, butter, fruit, or metals. Many of the first ships that came to Australia returned to Great Britain with timber, and builders

there learned to know the toughness, strength, weight and handsomeness of Australian hardwoods.

About 60 species of eucalypts are exploited commercially for timber. Only two Australian States at present have export surpluses—Western Australia and Tasmania. The output of sawn hardwood timber from Crown eucalypt areas for the year ending June 30, 1943, was 500,000,000 super feet. An additional 150 to 200 million super feet was taken from private property.

Taking Australian eucalypt woods as a whole, you can divide them into two great classes—the coloured or red woods and the pale woods. Most of them have a density (relative to weight of water in a cubic feet; 62.4 lb.) of 45 to 75 lbs. a cubic feet. Two of them—*karri* (*E. diversicolor*) and *tuart* (*E. gomphocephala*) are so strong that they have been used to replace steel in trucks. Many of them are exceedingly beautiful in grain and colour. Some of the best are: red mahogany (*E. resinfera*), *jarrah* (*E. marginata*), two of the boxes (*E. polyanthemos* and *E. Rudderi*) *wandoo* (*E. redunca*), yate gum (*E. cornuta*), slaty gum (*E. Dawsoni*), salmon gum (*E. salmonophloia*) river red gum (*E. rostrata*), spotted gum (*E. maculata*) and mountain grey gum (*E. goniocalyx*).

King of the Australian eucalypts is the giant mountain ash, one of the world's biggest trees, and probably only overtopped by the Sequoias of North America. These trees grow above the 300 ft. mark in the mountains of Victoria, and New South Wales.

There are bushmen's claims in the past of having measured giant mountain ash trees over 500 ft., but the official Australian record is that of the Thorpdale (Victoria) tree which a Government surveyor in 1880 measured to be 375 ft.

The mountain ash timber is pale-coloured and resembles that of the English ash. It has many commercial uses. It is a half-bark and is classified among the blackbutts.

Western Australia, too, has its tall timber. The tallest known living *karri* (*E. diversicolor*) grows in the National Park; it measures 275 ft. Another giant nearby is 269 ft. high and 159 ft. from the ground to the first limb. One famous tree, the "King Karri", as it was called, was 342 ft. high.

Another big *karri* (265 ft.) gave 62,200 superficial feet of sound timber, weighing about 120 tons, exclusive of branches.

Karri is classified according to the bark among the gums proper. It is a deep red-coloured timber, hard, heavy and tough with an interlocked grain; it is famous for building purposes. Its bark is used for tanning leather.

The Western Australian *jarrah* (*E. marginata*) is another famous timber tree. It does not grow as tall as the *karri* or the mountain ash, but its rich red, medium hard timber is almost waterproof and resists fire and boring insects for outside work it needs only oiling. Another fine Western Australian eucalypt is the *wandoo* or white gum (*E. redunca*). Its timber closely resembles *jarrah* and has been classed with it as among the best for railway sleepers. *Wandoo* sleepers have been known to last for 50 years —longer than even jarrah.

Blue Gums in India

Of the Australian eucalypts that have emigrated overseas, probably the best known is *E. globulus* (button-like), the specific name, globulus, being a description of the top of the seed vessel. Another emigrant is *E. bicostata* closely related to *E. globulus*. Both these are commonly known as the blue gum—and in California, as the Californian Gum. Both are smooth barks or gum propers.

In India the blue gums are called the Fever Tree; they are planted in swampy country as a malaria preventive—mosquitoes are allergic to the strong eucalyptus oil of the trees. The blue gums grow well also in Italy, Spain, the south of France, the Cape of Good Hope and Algeria. These trees have a smooth whitish-blue bark.

Wherever eucalytps are grown, the seed for planting originally came from Australia. Growing from seed is the only practical way because it is difficult to bud or graft saplings.

Tucked away in unexpected places in the forest areas of South-Eastern Australia you will come across families engaged in the ancient task of distilling oils from leaves by the simple use of heat and condensation. Their somewhat lonely work gives the city folk their stocks of eucalyptus oil for use medicinally, or as a cleaning agent.

And you may have heard in the Australian song "Waltzing Matilda" of the swagman who camped "under the shade of a coolibah tree". The coolibah is a eucalypt too.

EXTRACTS

RECREATION IN WILDLAND MANAGEMENT

By S. T. Carlson.

Regional forester, National Park Service, Santa Fe, New Mexico. Senior Member, S.A.F.

The Inland western mountain region* contains a vast wealth of recreational resources. Here we find that the topography ranges from a few hundred feet above sea level in the Sonoran Deserts to lofty mountain peaks over 14,000 feet high. Attendant with the variations in topography and climate are corresponding variations in the vegetative cover and wild-life. We find lakes both natural and man-made mighty rivers and canyon glaciers, hot springs, and other natural features which we have come to recognize as having a recreational use and value. This region is a paradise for the recreationist.

Just what is recreation as applied to wildland? For purposes of this discussion, recreation may be defined to mean those outdoor activities of a leisure-time nature which are diversionary in character and afford physical, intellectual, and inspirational experiences. Recreational resources may be defined to mean those cultural or natural features which stimulate, encourage, or provide for recreation.

Increasing Demand for Forest Recreation

Today, recreation is an extremely important phase in the management of wildlands, and we can look for it to become more important in the future. Improved and speedier means of transportation, together with a shortened work-week and paid vacations are bringing more and more people into the wildlands. Consequently, many of our present recreational facilities are inadequate to accommodate the use they are receiving and are deteriorating under this heavy usage. An overcrowded campground, or one in which the vegetation has been reduced to a few trees detracts from its value for recreational purposes ; it is akin to overgrazing. It demands

*Construed to mean the states of Motnana, Idaho, Utah, Colorado, Wyoming, New Mexico, Nevada, and

the development of additional, unused recreational resources or, if this is not accomplished, eventually results in a loss of use.

Communities in and adjacent to recreational areas are beginning to realize that the recreation dollar is a source of steady and lucrative income—in some instances, a more profitable one than if the land were utilized for the production of wood or for grazing purposes. This stimulates additional demands for the development of our recreational resources and may require the withdrawal or reduction of other Land uses in that area or adjacent areas.

The Bureau of Reclamation and the Corps of Engineers U. S. Army, have included in their surveys of proposed dam sites and water reservoirs, detailed studies of the recreational uses and values of each project. They have recognized that there are economic or monetary values on the potential benefits which result from recreational use of reservoirs.

Co-ordinating Wildland Uses Requires Careful Planning

Thus, the forester in managing wildlands is not only confronted with an increasing demand for recreational facilities, but must correlate these developments and activities with other land uses. He must weigh and determine the extent to which he will promote any one use, perhaps at the expense of eliminating or curtailing another use. For example, grazing is not compatible with campground or picnic ground use and in most instances is not permitted ; it might be desirable for aesthetics or wild ife purposes to eliminate or restrict grazing along a scenic road, trail, or other human-use area. Another example is the elimination of timber cutting or applying modified cutting practices in highly scenic areas. An indefinite number of examples can be cited in which land uses and values must be carefully considered in the recreational management of wildlands.

Obviously the work of the wild land manager would be greatly simplified if the area involved were devoted to one single use. It would be difficult to conceive of one of our administrative units in which the use of that unit would be for one purpose only. Even so, in an area which is devoted solely to recreation, the types of use utilized may be in conflict with each other. Therefore, the management of a unit or area requires very careful planning, in which all the contemplated land uses are co-ordinated.

Recreational planning is based largely on human use and the relative value of the land resources devoted to that purpose. It is of necessity long-range planning in which the local, regional, and national goods are considered. Recreational planning and development involve the advices and cooperation of the various civic societies and organizations, planning boards, together with other wildland managing agencies. This not only prevents duplication and conflict of recreational developments, but makes for the wisest overall land use.

Recreational Facilities

A majority of the present-day wildland recreational facilities in this region are in the national forests, parks, monuments, and recreational areas.* There are a few state parks, but very little has been done in the way of recreational development or use of state or private lands. Recreational facilities on private lands consist principally of "dude ranches" and hotels, inns, and resorts. These are usually within adjacent to federally owned lands. A summary of the recreational areas or developments which I have termed facilities number around 28 and are as follows :

1. Campgrounds
   a. Trailer camps
2. Picnic areas
3. Organization camps
   a. Government
   b. Private
4. Resorts, hotels, inns
   a. Government
   b. Private
5. Sports areas
6. Winter sports areas
7. Summer home sites
8. Service or utility areas
9. Roadside zones
10. Trail zones
11. Lakes, reservoirs, streams
12. Observation points
13. Waterfront zones
14. Buffer zones
15. Wilderness areas
16. Wild areas
17. Roadless areas
18. Virgin areas
19. Natural areas
20. Archaeological areas
21. Geological areas
22. Historical areas
23. Scenic areas
24. Research areas
25. Scenic roads and trails
26. Natural history museums
    a. Roadside or trail-side musseums
    b. Arec
27. Campfire circle or amphitheatre
28. Landing fields

Aside from the mileage and number of roads and trails which facilitate other uses besides recreation, summer homes, campgrounds, picnic areas, and trailer camps respectively constitute the greatest number of recreational facilities ; these facilities provide for more human use than any other facility. In some

* Only one in this region, Boulder Dam Recreational Area.

recreational areas the use is so heavy and concentrated that it has become necessary to limit the visitor's stay to a definite number of days. Estimates for future recreational developments indicate the greatest need for more campgrounds, picnic areas, trailer camps, and summer homes. These developments in turn will require additional area, roads, trails, and service areas.

One type of development which looms up in wildland recreational management is the use of aircraft and landing fields. At the present time there are relatively few landing feilds in our recreational areas and they are not recognized as a recreational facility. They are used only for administrative or protective purposes and the public is prohibited from using them except for emergency landings. There are, however, numerous commercial landing fields adjacent to the recreational areas. It is not difficult to foresee that there will be a demand for public use and development of aircraft and landing fields within our recreational areas, on both land and water, and this feature requires study and consideration.

Some Problems in Wildland Management

It has been previously mentioned that very careful planning is necessary in wildland management in which all contemplated land uses are co-ordinated. In the overall planning the question of relative values arises. We can at the present time place a fairly equable value on land utilized for grazing purposes or for land containing merchantable wood. We have no workable methods or formulae for measuring or appraising and expressing in dollars forest recreation values. Another place where we need a method for determining recreational value is in fire or other trespass, or recreational lands and in the purhase of private lands within our recreational areas.

Trained recreational specialists are needed in recreational planning and management of recreational areas. Lewis Turner in a recent Journal article* has suggested a curriculum for training for work in wildland management. For the needs in this western region, he has proposed a combination of five elements, namely timber, range, wild life, recreational and watershed management, and the establishment of an appropriate civil service examination.

Should fees be charged for the use of recreational facilities? Timber and forage, products of our wildlands are sold; fees are charged for special uses such as summer home sites, resorts, and inns. Isn't recreation use a product of our wildlands and isn't it fair to assume that this should be sold? If not, should not some rental be collected on government installations ?

—*Journal of Forestry*, 44, (11) November, 1946.

NEW DEVELOPMENTS IN TIMBER RESEARCH†

BY KATHLEEN COURLANDER

Before the present century the technology of wood received little attention and few people realised that the term "timber" covered many varied materials, each possessing specific structural characters and properties. Wood was regarded, in fact, as a commonplace commodity which was used wastefully.

The need for research in this respect was recognised in Britain in 1920 when the Imperial Forestry Conference made a recommendation which led to the establishment by the Government of a Forest Products Research Board, under the Department of Scientific and Industrial Research. Its functions were the organisation and maintenance of research into the utilisation of timber and other forest products. By 1925 the Government had built up the nucleus of a Forest Products Research Laboratory which, two years later, was installed in new buildings at Princes Risborough, Buckinghamshire, and subsequently, with the aid of a grant from the Empire Marketing Board, the activities of the laborartory were extended.

In the industrial world of the reconstruction period after World War II, the most efficient and economic utilisation of timber will be demanded. Britain's manufacturers will

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*Turner, Lewis. Training wildland managers. Jour. Forestry 44: 491-96. 1946.

†Release No. F. 796, dated 18th July 1947, by the United Kingdom Publicity Services, Post Office Box 110, New Delhi.

have to face competition from goods made of wood in foreign countries, and from articles made from metal and plastics. To meet this competition successfully, it will be necessary to give more attention to the selection of the best species of timber for any special use ; only the correct grade, satisfactorily seasoned, should be used.

Subjects of Study.

This is where the work of the Forest Products Research Laboratory is helping. The Laboratory is divided into a number of sections, each in charge of a specialist in some branch of wood technology which is available for co-operative action on any general problem.

The subjects of study are summarised under different categories. First there is the structure of timber in relation to its properties. Here it is pointed out that the structure of wood is extremely variable and that the cells which may be regarded as the structural units, vary in proportion, shape, size, orientation and thickness. This wide variation in structure is reflected in the weight, hardness, strength, working qualities and practically all other properties and opens an extensive field of research.

The moisture relations of timber comprises another section, for water is essential to the growth of a tree, being one of the simple chemical compounds from which the very complex substances of the cell walls are composed. The advisability of reducing this water before the timber is used in manufacture has been recognised for centuries but it is only in recent years that the moisture relations of woods have been scientifically studied and their full significance understood.

A new field of development has been opened in the bending properties of wood. These bending properties are used in certain industries and reliable information is needed. Recently the advantages of making bends of laminated, instead of solid, woods have begun to be recognised.

Strength of Composites

The strength of timber is an important subject of research. The strength of composites which have wood as a major component must be investigated as well as the various grades of the commoner structural timbers. The effect of knots, wild grain and aberrant growth characters on strength properties requires research. The design and construction of packing-cases, crates and boxes related to the materials used in their manufacture have been studied systematically.

Different timbers show as much variation in their durability as in their other properties. Study of methods of increasing the natural resistance to fungal decay by artificial means is made and the treatment of wood to render it non-inflammable and fire-retardant requires further investigation.

The woodworking section considers the wide differences in structure, weight and other properties of commercial timber in connection with machining processes. New problems calling for research in connection with tools and machine design have arisen from the advent of composite materials which have wood as a major component.

Further work is required in the study of composite wood to determine the best methods of rendering non-durable woods in composite form resistant to decay and to discover exactly how the preservatives and adhesives will react on one another.

Free Advisory Service.

Wood substance and the cell, contents of wood are the natural food of different insects which may be responsible for causing serious deterioration in timber. The physiology of the different species must be studied with a view to preventing damage and the merits of recommended preservative treatments must be investigated.

The field of research in connection with wood chemistry covers the chemical composition of the various cell-wall substances, particularly cellulose and lignin, and their separation and recovery. The rapid developments in the past few years of new adhesives have involved much chemical research.

The physical properties of wood are intimately related to its strength, seasoning and behaviour in working, and such subjects as the diffusion of heat and gases in wood, its elastic properties and similarly purely physical properties should be investigated. Physicists and chemists together form a background of pure science for the work of the applied science sections.

The Forest Products Research Laboratory which has a library of reference books and publishes data in popular, as well as scientific

language, has always maintained an efficient, free advisory service. This, with the background of 20 years' experience and the contacts established with similar laboratories in the Dominions and America, has met practically all the demands of the wood-using professions and industries. When conditions become normal again, after the years of World War II, it is proposed to make available all information bearing on peace-time industrial processes which accumulated during the war years.

AN ANALYSIS OF INDUSTRIAL FORESTRY

BY FRED J. SANDOZ *

This analysis was prepared by the author, with the assistance of his brother, for the purpose of promoting better forestry on privately owned forest lands through a better understanding of the activities and responsibilities of the industrial forester. Although it applies specifically to the Pacific Northwest, the principles that it stresses are also applicable in other regions. Some of the material pertaining to fire protection and forest management was taken from articles that previously appeared in "Random Lengths," published by Willamette Valley Lumbermen's Association.

The primary objective of this report is to promote practical forestry on forest lands in private ownership.

Many foresters returning from the war and others soon to be graduated from universities are seeking employment in the industrial field. Some will make a few contracts with prospective employers and become discouraged because they will find themselves inadequately prepared; and they will find also that many companies are not properly informed about the value of service available to them, the type of personnel to employ, the wisest use, and the cost of forestry.

A number of these foresters will be employed and later awaken to the realization that they themselves are not properly prepared to produce the results desired. Some will find their employers have acquired false and improper ideas about forestry.

In analyzing industrial forestry, one learns that the industry is not generally at fault because private enterprise under the American competitive system will seldom pass the opportunity to place an investment where it will return reasonable dividends. Some companies have learned, and the practical industrial forester knows, that sound forestry pays reasonable dividends. It has been my experience to see companies lose thousands of dollars because they lacked or failed to utilize the services of a competent forester on inventory of forestry property alone. We are all familiar with losses from fire that have occurred and should have been prevented.

Some industrialists have a wrong impression of forestry because they had seen it only as practised by governmental agencies. Some government foresters lack the profit philosophy that is required in industrial work. The fact that the industry is often exposed to the government's trainee or most inexperienced foresters has produced a failure in forestry salesmanship.

The small percentage of successful industrial foresters is due to inadequate university training and little on-the-job training. The demand for industrial foresters should be anticipated and studied by the schools with a view to graduating competent men for placement in industry. These men should know what they are talking about instead of searching their minds to make a successful interview. The industry should accept beginners as such and capitalize on them by giving them the experience and training that is needed.

An industrial forester's responsibility is collecting, analyzing, synchronizing, and reporting the economic and silviculture aspects of forestry information pertaining to company and allied forests to the industry directly concerned.

This report is designed to indicate clearly the responsibility and authority of the position of forester to promote greatest efficiency and to eliminate much "bull cooking" and other miscellaneous unrelated details, now erroneously and wastefully delegated to this position. It is hoped that it will help industrial foresters to orient their thinking and clearly to appreciate their mission.

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Differences in type of forest land, size of holdings, co-operative setup, and types and sizes of manufacturing plants influence the character and quantity of needed forestry service. The following analysis covers the complete picture but will not all apply to every forest unit. The forestry service and organization necessary must be decided individually for each unit.

Much of the work discussed under the forester's work plan is being handled by members of the managerial staffs of the timber companies. The need for the information outlined and the release of over-burdened managerial staffs to their regular duties should be the basis for the employment of an industrial forester.

The report is also designed to serve as a guide to the industry on the character, organization, and cost of forestry work.

THE INDUSTRIAL FORESTER

An industrial forester is a professional man trained and experienced in the science and art of growing trees on lands privately owned for purposes of industrial harvest at a profit.

TRAINING AND JOB CLASSIFICATION

Some timber companies have instituted a training programme for foresters similar to that for lumber salesmen and logging foremen. This is done by selecting good raw material and developing the individual through a series of jobs until he becomes experienced and seasoned in forestry work of all types and its relationship to logging, manufacturing, and consumption of forest products. These jobs include :

Indoctrination and orientation for a few weeks each as choker setter, muck sticker, loader, tractor operator, bull buck, pond man, lumber piler, and retail yard man.

Forestry apprentice work for a few months in any one job such as dispatcher, tree planter, fireman, compassman, lumber grader, road locator, lumber salesman, lookout, or draftsman.

Semi-professional forestry work for a few seasons as cruiser, log buyer, land examiner, timber marker, fire foreman, mapper and surveyor, and scaler.

Professional forestry work for a few years, including active participation in any one of the first five departments outlined below in the Forester's Work Plan, but varied through the years between departments.

Administrative professional forestry work for many years involving the administration of all types of forestry work from one office.

The time spent on any one of these jobs and on all training is dependent on local conditions, personnel problems, and the individual's ability to assimilate training. It must also be recognized that foresters must always seek to train themselves, regardless of position held.

FORESTER'S QUALIFICATIONS

A competent forester is an individual who has been trained in the profession of forestry at a recognized school of forestry or who has obtained essentially the equivalent of such training through practical experience. He should have at least five years of varied experience in the logging and lumbering industry, and in at least one government forestry agency, and should preferably have had boyhood farm or woods experience.

The forester should have ties with others in his profession to keep himself informed on the latest developments and modern methods of forestry practice. He should have ample native ability and common sense, and he should be able to express himself clearly and concisely in writing and speech.

These qualifications are the minimum necessary for a man to assume the position of forester for a company or to carry on forestry professional work as outlined in this report.

INDUSTRIAL FORESTER'S POLICIES

The responsibilities of a forester to his company and community demand that he be a leader in civic affairs as well as in his professional work. Such a leader will win community improvements that will benefit his company in unlimited ways.

A good forester must have high ideals in promoting the best interest both of the public and of his employer. Much of the information which he handles is confidential because it deals with the financial and management policies of the company that directly and indirectly affect the whole community dependent on the company's operations.

The forester must have definite policies that support good business practices in the timber

industry. He must believe that timber is a crop and not a mine. He must believe that forestry planning starts before trees are cut. His objective must be continuous production of forest crops for profit from the lands with which he is dealing.

WHY EMPLOY A FORESTER

Forests are a valuable renewable natural resource when managed properly. Forest resources have every promise of retaining and increasing their high value for many generations to come. The science of growing forest crops economically is too vast and involved for the average business man to comprehend and at the same time devote the necessary attention to other business activities.

An informed forester must, therefore, serve as the owner's interpreter and adviser in the management and utilization of his forest lands. Properly employed, he will prove to be an investment that will earn many times its cost over a period of years.

World War II and forest-resource studies have demonstrated a shortage of timber supply that has made the industry realize that to continue in business it will be necessary to replace its resources by growing trees. All substantial timberland owners should secure the services of competent foresters to increase the value of their lands through proper forest management and to insure a continued successful business.

CLASSIFICATION OF FOREST LANDOWNERS

The extent to which forestry services can be of value to forest owners will vary with the size of the ownership (which affects financial ability to pay for services), and the personnel which the owner has in the organization. In order to provide a basis for discussion, forest owners are divided into three broad classes.

The *small owner* is one who does not have sufficient area for continuous production. He cannot ordinarily afford a full-time forester. However, by being a member of a co-operative forest management enterprise, or by employing a consulting forester the small owner can obtain professional services in such activities as timber cruising, marking and scaling, mapping and surveying, fire protection, slash disposal, inventory of cutover lands, planting, and road location. Membership in a co-operative setup entitles the small owner to be represented by a forester in contact with the state board of forestry and other public agencies and associations.

The *medium-sized owner* is one who produces from 25 to 50 million board feet per year. A forester can easily save at least his expenses and often much more on this size of operation, which is the minimum that should have a full-time forester under present standards. A medium-sized owner can derive additional benefits by membership in a co-operative forest management organization or by conference with consulting foresters, who can help by:

1. Furnishing guidance to the company forester, and supplying any information or training necessary.

2. Keeping the company forester informed on forestry dev elopments, techniques, and research which he does not have time or contacts to learn.

3. Formulating long-range forest management plans and programs which the company forester does not have time to make because of the pressure of immediate jobs.

The *large owner* is one who produces better than 50 million board feet per year. He should have a forester and staff as needed.

THE FORESTER'S WORK PLAN

The industrial forester's work should be segregated into seven separate activities.

PUBLIC RELATIONS

The success of a managed forest will depend to a large degree on co-operation of the public in and near the forest area. The public must be educated to recognize the hazards of fires, of overgrazing, and of trespass cutting. This education must be accomplished by the forester through the medium of newspapers, magazines, signs, speeches, radio talks, conferences and letters.

The forester must educate county courts on proper disposition of tax-delinquent lands to mantain them on tax rolls and to get them into production.

Where involved, the forester must inform the city water boards on proper management and wise use of their lands.

The forester must not neglect the opportunity to educate neighbouring operators and forest owners on practical management of their lands.

The national tree-farm movement has developed some confusion between "tree farms" and "sustained yield." An area of forest land is not operated under "sustained yield" unless it permanently yields uninterrupted, uniform supplies of forest products. A given area can be operated under sound tree-farming (forest-mangement) principles, however, and yield only one crop every 50 years. For example, a forest tract of 100,000 acres could grow enough raw material to sustain permanently a manufacturing plant with a capacity of 30 million board feet per year; a forest tract of 100 acres could grow only enough raw material to supply the same plant for about a month in an 80-year period. Both tracts could be operated as "tree farms," but only the first would have "sustained yield."

FOREST PROTECTION

Fire protection.—It should be clearly understood that in fire protection the industrial forester functions only in a consulting, advisory, and supervisory capacity. It is his duty to employ and discharge the fire warden and watchman as needed on the company operations. It is a major function of the forestry office to analyze the protection work on the company unit and to recommend measures which appear necessary to secure adequate protection of both mature and immature stands and cutover land.

The master fire plan includes a complete analysis of the protection problem for a given forest unit, and recommends measures considered necessary to secure desired standards of protection. These recommendations may outline a general work programme for 5 to 10 years.

The analysis of the protection job requires collection, recording, and study of information concerning many factors, including the fire history of the unit, existing fuel types and fire hazards, fire detection and communication, and transportation facilities. Maps are a valuable means for recording and studying much of this information.

Out of this mass of data come the recommendations of measures considered necessary to do the desired job. These will vary with the characteristics of each area, but can be boiled down to four fundamentals:

1. Detection—the fire must be seen by some one.

2. Communication—whoever sees the fire must tell suppression forces.

3. Transportation—adequate suppression forces must be gotten to the fire.

4. Suppression—fire-fighting personnel and equipment must be adequate to put out the fire economically.

The master fire plan outlines an activity programme for a period of years; the yearly fire plan outlines activities for the current year only. This yearly plan is prepared in co-operation with the individual who has charge of the protection activities of the company, such as the fire foreman. It outlines fire-prevention measures and plans for crew and equipment to control fires which may occur.

Fire-protection inspection service is directly comparable to that rendered by insurance underwriters in mills. Periodic, impartial inspections of the planned protection measures for each forest unit are made, and a standard report is submitted to the management. The theory is that an impartial, outside inspection will notice items overlooked by those closer to the job; the objective is to improve fire protection.

Slash handling.—It is becoming increasingly apparent that slash-disposal is one of the biggest single factors in forest management. One mistake can destroy forest values which it may take 100 years to replace. Many decisions regarding disposal of slash must be made months before the slash-burning season. Decisions as to areas to burn and those not to burn; on logging plans; methods of burning; snag falling; and firebreaks—these are all items which must be considered for each slash-disposal unit. Such decisions cannot be made on the day burning permits are issued: they must be based on adequate thought and advance planning. Slash burning will be supervised by the forester and executed by the fire foreman and crews.

The fire-protection report is a summary of the year's fire-protection activity. It includes information on accomplishments, on individual fires, and on costs and losses. Its purpose is to record work done and results achieved in a form which will be valuable for planning of future activities. Costs of fire-protection and slash burning can be expressed on an acre or volume basis.

Insect and disease damage.—Provision must be made for inspection, control, and salvage.

Trespass.—Responsibility must be determined in all cases of fire and timber trespass, and the damage evaluated.

Grazing.—Grazing by livestock must be constantly investigated and necessary control measures undertaken to eliminate damage to the forest.

FOREST OPERATION

Forest operation is the practical application of good forestry practices. This may be accomplished directly by the forester or his subordinates, or indirectly through the company officials or their subordinates. Forest operation covers the following subjects and activities:

- Logging plans and practices.
  - Recording progress.
  - Fitting plans to forestry and forestry to plans.
  - Reserving growing stock.
  - Planning for seed source.
  - Location of timber for loggers to fulfil market demands.
  - Road location.
- Conservation act.
  - Seeking compliance with laws.
  - Investigation and correction of violations.
- Forest taxes.
  - Location and report of areas for reforestation act.
  - Reporting and valuation of cuttings subject to the yield tax.
  - Listing forest property subject to the *ad valorem* tax.
  - Reporting lands for fire-patrol assessments.
  - Timber-depletion tax reports.
- Timber sales.
  - Administer company sales.
  - Act as company agent on forestry matters on government sales.
- Tree-farm status.
  - Effect practices of tree-farm standards.
  - Obtain certification from West Coast Lumbermen's Association and registration of tree farm from Forest Conservation Division of N. L. M. A.
- Marking timber.
- Supervision of logging contracts.

FOREST MANAGEMENT

Forest management is the inventory, study, and planning of the financial and forestry possibilities of the forest lands included in the operating unit.

Preliminary analysis.—The first job in forest management is to make a preliminary analysis of the forest property involved to determine the best size and boundaries of the unit, the yield capacity, allowable cut, acquisition and co-operative possibilities, risk factors, and costs.

From available type maps, aerial photographs, site maps, and inventories which include records of cutover lands and cruises, the following forest statistics must be complied and incorporated into a preliminary management plan:

1. Total land area.
2. Forest land area.
   - Coniferous sawtimber.
   - Coniferous second growth.
   - Hardwood areas.
   - Deforested cutover and burns.
3. Sawtimber volume.
   - Old-growth Douglas-fir.
   - Large second-growth Douglas-fir.
   - Other.
4. Site quality of commercial coniferous areas.
5. Degree of stocking in immature coniferous types by ages.
   - Area of each forest type.
6. Average annual sawtimber depletion.
   - Sawlog production.
   - Fuel and other.
7. Current annual growth.
8. Forest ownership.

Management plan.—Following the preliminary analysis, the preparation of a management plan for each forest unit is in order. The management plan will budget the timber cutting by allowable annual cut and direct the location, methods, and sequence of cutting. It must be practical from a business standpoint as well as sound from a forestry standpoint. It must be based upon the best information available and a thorough knowledge of actual forest conditions. A good management plan requires considerable time, study, and detailed information derived from forest inventories and a study of logging methods.

Revisions of management plans.—The forester's management work includes revisions of management plans whenever necessitated by changes in ownership, boundaries of the units, or better information.

Inventory.—Forest lands, whether they are to be held for timber growing or to be bought, sold, or exchanged, require an examination and appraisal to determine their value. In old growth, commercial cruises are usually available, and where checks indicate the cruise to be reliable they may be used as a basis for yield calculation or market valuation. In second growth and reproduction areas, there is usually a complete lack of information upon which to base appraisals. Examinations on which to base such appraisals vary from a general "land-looker" observation, which is a rapid and economical examination of a tract commonly made to size up a prospective purchase or sale area, to the regular four-run cruise where an accurate estimate of old growth is desired.

Generally, the intensity of the inventory should be in proportion to the value of the forest crop examined. Its advantages include :

1. Availability of basic data in statistical and map form for ready reference in the development of current protection, logging, and forest management plans.

2. Provision of a basis for the development of plans that will provide a balanced production of species and grades for the current requirement of the manufacturing plants and still leave a balanced timber supply for future consumption.

Indication of impending changes in the type of forest products that will be produced long enough in advance to allow the processing departments to make necessary adjustments in their plans of operation and the sales departments to begin development of new markets if necessary. In a like manner, as the requirements of markets change, logging can be more readily shifted to timber types which will, with a minimum amount of waste, furnish the proper proportion of species and grades.

Other land use.—The forest unit studied may have other profitable uses besides timber production that can be co-ordinated into the management of the land or administered on a segregated portion of the unit. The forester must analyze such possibilities as mining, grazing, or recreation use and report on the economics of their application.

Analysis of sustained-yield possibilities.—This work involves the assembling of all existing information, analyzing the composite data, and preparing a report as to the possibilities of establishing a sustained-yield unit. Such items as ownsership pattern, forest types, age-class distribution, stocking, site, probable sustained-yield, accessibility to markets, co-operative possibilities, competition, fire, and other risks are all taken into account in this analysis. The study and report are designed to provide, in the most economical and rapid manner, a basis upon which the company can develop further action toward establishment of a unit.

The forester should seek eventual lowered forest taxes on sustained-yield units as an aid in their extension and in permanent planning.

Co-operative sustained-yield agreements.—Co-operative sustained-yield agreements must be sought if the company holdings are not large enough, or if the age classes are too poorly distributed, to sustain forest cropping. Such agreements may be made with the O. & C. Revested Lands Administration, the U. S. Forest Service, or other adjoining forest owners whose lands may be essential to round out a satisfactory sustained-yield unit. The procedure varies according to the ownership of the adjoining lands. The Forest Service has recently issued an outline of information desired in an "Informal Application for Co-operative Units." The O. & C. does not have such an outline or informal application to follow, but secures similar information through study of local conditions, and attempts to bring about co-operative agreements with the most desirable forest owners, within the O. & C. established units. The matter of contractual agreements is one remaining to be worked out.

Available information indicates that co-operative agreements will be planned on the basis of resource data and the applicant's plans and community benefits.

Resource data will show by map the boundaries and ownerships of the proposed unit. A chart showing total acreage by ownership and major timber types will be included, together with a table showing merchantable volume of timber separately by ownership and types.

The applicant's plans and community benefits will include a brief history of the company, with a statement of existing and planned operating and manufacturing facilities ; planned disposition of logs if not to be entirely processed in applicant's plants ; planned future rate of

cutting from the unit; plans for additional land or timber acquisition, if any, or other information necessary to a clear presentation of the applicant's case; number of employees currently engaged in operations and number required for operation as planned on a sustained-yield basis; and relationship of company's contribution to the local employment base and to the tax bases of the community and country.

Acquisition surveys and evaluations.—An activity whose need becomes apparent when forest units are analyzed for sustained-yield organization is that of forest land acquisition to consolidate ownership and to bring about the best possible distribution of timber stands by age classes.

The acquisition survey must be based on a general work plan that will give a description of area covered, the forest picture, ownership, logging and fire history, and land values.

Each tract examined must be reported on a prepared form that indicates the legal description, owner and address, tax status, stocking, species, age, area, forest description, fire hazards and risks, availability and price, examiner's evaluation, and recommendations.

Evaluation of forest land must be based on present value of the current stand and all succeeding crops. The appraisal of mature timber is based on cruising. The appraisal of immature timber and of forest land must be based on the expected yield of the crop as indicated by conditions reported from inventories. The expected volume yield converted into dollars, reduced by the initial investent, subsequent costs, and interest, and discounted to the present gives the appraised value of the forest property.

Exchange surveys, evaluation, and negotiations.—Forest land values for land exchanges must be derived in the same manner as for acquisition.

The industrial forester must classify and evaluate the lands involved, and must recommend an exchange that will satisfy the purpose to be accomplished. This should be consolidation to facilitate management, to develop a sustained-yield unit, and to acquire an even distribution of growing stock on the operation unit.

FOREST RESEARCH

The industrial forester must obtain, investigate, and make practical application of research information from the federal forest experiment station, Weyerhaeuser Timber Company, state forestry department, and other organizations. He should be interested in studies dealing with logging costs, grade return, mill scale, relogging and prelogging, utilization of woods and mill wastes, and development of higher value products.

Because of local differences in the character of trees and stands, the forester may have to make studies to fit existing volume tables and data on growth and yield to the area being studied. New inventory methods to fit special conditions may need to be devised.

The establishment of a Demonstration Tree Farm Tract on the company operation has the twofold purpose of research and education. It provides a local, "on-the-ground" exhibit of the value and potentialities of "reproduction" and "second growth," and it furnishes a means of acquiring the information necessary for the sound management of forest property on a permanent basis. The demonstration tract should be approximately 160 acres in size; should offer a representative variety of forest conditions as represented by slopes, aspects, types, density of stocking, and age of stand; should be accessible; and should be managed intensively.

FORESTER'S REPORTS

The forester's annual report to the company management must show his organization, the work done and results accomplished during the past year, the plans for the next year, and the costs of his services to the company. It must be accompanied by a budget for the next year's projects and activities. Where possible, the return for money spent on forestry should be shown.

Progress reports must be prepared on major projects as requested. Final reports and maps must be prepared in concise, clear terms on the termination of each project, and submitted to the management for consideration and action.

RECORDS

The long-time nature of forestry work demands that accurate, systematic records be kept. These should be filed by subject-matter, under separate activity heads. No letters, orders, or information should leave a forestry office without exact duplicates entering the files. The files must be kept complete from field forms to final reports.

Complete accounting records for personnel and equipment costs must be maintained by activities.

Maps record a great deal of forestry and logging information and must be filed by activities in a separate file.

The advancement of forestry has produced many essential publications and these again demand a separate file by activity heads.

Administrative Position of the Forester

The institution of effective forestry practices in the operation of a timber company depends almost entirely on the management's ability to place the forester in his proper position in the company administration. This placement demands an analysis on the part of the management of the company's administrative organization and personnel policies.

It may be necessary for the company president or manager to educate or reorganize his management and employees to a co-operative and receptive attitude toward forestry. It is essential that the logging superintendent, logging engineer, logging foreman and all the loggers understand and co-operate fully on all forestry matters affecting their work. This understanding and co-operation is an essential part of their work for the company and it should be made an employment condition. A definite programme of education, to show each man the objectives and the relation of the work to his particular job, should be carried out.

Much of the forestry planning that must be integrated with the logging can be accomplished if the forester and logging engineer have a common objective and work out the details together.

The employment of men with forestry training in key positions in the logging organization will accomplish forestry objectives most efficiently.

Forestry objectives will meet many obstacles in personalities and policies that will prevent their being of full value to the company if these steps are not taken. The result will be a waste of the investment in forestry that would otherwise have paid its own expenses many times over.

Ultimately, the position of forester for a timber company to effectively institute practical forestry must be that of assistant to the president or manager, on forestry matters. This demands that the management recognize the importance of forestry and the most effective means of bringing about its practice. It also places on the industrial forester a great responsibility that he must recognize and accept.

It is necessary for the manager to receive forestry advice and information on important matters from the forester and then relay it to the other departments. Also, complete co-operation between the forestry and logging departments is imperative on all forestry measures that affect logging.

Timber companies must realize that if they fail to recognize the importance of these facts, they will not be able to obtain and retain forestry services from among the more competent foresters.

Forestry Staff, Equipment, and Costs

One great weakness of practising foresters is their failure to recognize and to analyze the costs of and returns from forestry. Placement of investments in business enterprises is preceded by a comprehensive analysis of the initial investment and operating costs of the venture as weighed against the profit to be obtained. The employment of forestry services is a business enterprise and must be justified in the same way.

Following are the estimated costs of a staff and equipment necessary to handle the work previously outlined. The staff may be increased by additional seasonal employees to execute specific projects in a shorter period.

Technical Staff (two men and office).

	Cost per month
Chief forester	$325.00
Field assistant	250.00
Stenographer	125.00
Social security	7.00
Industrial accident	70.00
Unemployment	7.00
Expenses, travel, meals, and lodging	100.00
Supplies, engineering, etc.	8.33
Office, phone, etc.	50.00
Stationery, postage	4.16
Drawing paper, blueprints, etc.	12.50
	$958.99

At 25 days per month, the cost per day is $38.36

EQUIPMENT	Initial costs
Automobile	$700.00
Abney level, chain, tape, tallywhack, pocket compass, staff compass, barometer, tatums, axes, map forms, pencils, etc. ..	147.00
Increment borer, diameter tape, Biltmore stick, scale stick, etc.	48.50
Letter, publication, and map files ..	30.00
Tables, T-square, drawing set, contour pen, triangles, map-edge binder, stereoscope, rules, inks, colored pencils, etc. ..	72.00
Typewriter, pen set, stapler, calculator ..	307.00
Books, bulletins, and periodicals ..	70.00

RECAPITULATION

Item	——Cost—— Per month	Initial investment
Personnel	$784.00	
Operation	174.00	
Field equipment		$895.50
Office equipment		479.00
	$958.99	$1,374.50

The expense of forestry services should be carried as a current operation cost figured on the basis of so much per acre or per thousand board feet of production.

The cost of the proposed industrial forestry staff for a forest unit averaging 35 M board feet per acre and a manufacturing plant cutting 150 M board feet per day will be $.29 per M or $.12 per acre for the first year, and $.26 per M or $.11 per acre annually through the first rotation. The costs per M will be reduced considerably during the second rotation because proper forest management will increase the yield capacity of the land to a marked degree. The forest unit would operate over an area of 104,448 acres, or roughly 4.5 townships, during the first 80-year rotation.

The expense of tree growing (forest management) carried as a current operation cost but handled separately from costs of logging, manufacturing, and sales should be regarded by the investors as a reinvestment in stumpage. All companies are familiar with the past practice of cut out and move on. Today, there are no new stands to move to, but the forest industry is most fortunate in having a natural resource that can be replaced and that will yield 3 per cent compound interest on the investment necessary to effect such replacement.

The investment by the stockholders in good forest practice and management on all the company lands is the only hope for the survival of the forest industries.

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